Aerodynamic Stall and Loss of Control During Approach
Embraer EMB-500, N100EQ
Gaithersburg, Maryland
December 8, 2014

Accident Report

NTSB/AAR-16/01
PB2016-103251

National Transportation Safety Board

NTSB/AAR-16/01
PB2016-103251
Notation 8626A
Adopted June 7, 2016

Aircraft Accident Report

Aerodynamic Stall and Loss of Control During Approach
Embraer EMB-500, N100EQ
Gaithersburg, Maryland
December 8, 2014

National
Transportation
Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2016. *Aerodynamic Stall and Loss of Control During Approach, Embraer EMB-500, N100EQ, Gaithersburg, Maryland, December 8, 2014*. Aircraft Accident Report NTSB/AAR-16/01. Washington, DC.

Abstract: This report discusses the December 8, 2014, accident in which an Embraer EMB-500 airplane (marketed as the Phenom 100), N100EQ, registered to and operated by Sage Aviation LLC, crashed while on approach to runway 14 at Montgomery County Airpark, Gaithersburg, Maryland. The airplane impacted three houses and the ground about 3/4 mile from the approach end of the runway. A postcrash fire involving the airplane and one of the three houses, which contained three occupants, ensued. The pilot, the two passengers, and the three people in the house died as a result of the accident. The airplane was destroyed by impact forces and postcrash fire. Safety issues relate to the need for a system that provides automatic alerting when ice protection systems should be activated on turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions, such as the EMB-500; and the need for training for pilots of these airplanes beyond what is required to pass a check ride. Safety recommendations are addressed to the Federal Aviation Administration, the General Aviation Manufacturers Association, and the National Business Aviation Association.

Contents

Figures

Abbreviations

AFM	airplane flight manual
AFSS	automated flight service station
agl	above ground level
AOA	angle-of-attack
ATR	Avions de Transport Régional
AWOS	automated weather observing system
CBA	cost-benefit analysis
CFR	*Code of Federal Regulations*
CTAF	common traffic advisory frequency
CVDR	cockpit voice and data recorder
DUATS	direct user access terminal system
EASA	European Aviation Safety Agency
ECTS	Embraer CAE Training Services
FAA	Federal Aviation Administration
FSB	FAA Flight Standardization Board
GAI	Montgomery County Airpark
IFR	instrument flight rules
IGX	Horace Williams Airport
IMC	instrument meteorological conditions
msl	mean sea level
MWL	Most Wanted List
NBAA	National Business Aviation Association

nm	nautical miles
NTSB	National Transportation Safety Board
NWS	National Weather Service
OPERA	optimized performance analyzer
PFD	primary flight display
PIREP	pilot report
POH	pilot operating handbook
QRH	quick reference handbook
RNAV	area navigation
SOP	standard operating procedure
SWPS	stall warning and protection system
TAT	total air temperature
V_{ac}	approach climb speed
V_{fs}	final segment speed
V_{ref}	landing reference speed

Executive Summary

On December 8, 2014, about 1041 eastern standard time, an Embraer EMB-500 airplane (marketed as the Phenom 100), N100EQ, registered to and operated by Sage Aviation LLC, crashed while on approach to runway 14 at Montgomery County Airpark (GAI), Gaithersburg, Maryland. The airplane impacted three houses and the ground about 3/4 mile from the approach end of the runway. A postcrash fire involving the airplane and one of the three houses, which contained three occupants, ensued. The pilot, the two passengers, and the three people in the house died as a result of the accident. The airplane was destroyed by impact forces and postcrash fire. The flight was operating on an instrument flight rules flight plan under the provisions of 14 *Code of Federal Regulations (CFR)* Part 91. Visual meteorological conditions prevailed at the time of the accident.

Data from the airplane's cockpit voice and data recorder (CVDR) indicated that the takeoff about 0945 from Horace Williams Airport, Chapel Hill, North Carolina, and the cruise portion of the flight were uneventful.[1] CVDR data showed that about 15 minutes after takeoff, the passenger in the right cockpit seat made a statement that the airplane was "in the clouds." A few seconds later, the airplane's engine anti-ice system and the wing and horizontal stabilizer deice system were manually activated for about 2 minutes before they were manually turned off. About 6 minutes later, a recording from the automated weather observing system (AWOS) at GAI began transmitting over the pilot's audio channel, containing sufficient information to indicate that conditions were conducive to icing during the approach to GAI.[2] The CVDR recorded no activity or faults during the rest of the flight for either ice protection system, indicating that the pilot did not turn the systems back on.

Before the airplane descended through 10,000 ft, in keeping with procedures in the EMB-500 *Pilot Operating Handbook*, the pilot was expected to perform the Descent checklist items in the *Quick Reference Handbook* (QRH), which the pilot should have had available in the airplane during the flight.[3] Based on the AWOS-reported weather conditions, the pilot should have performed the Descent checklist items that appeared in the Normal Icing Conditions checklist, which included turning on the engine anti-ice and wing and horizontal stabilizer deice

[1] The airplane was equipped with a combination solid-state CVDR capable of recording 2 hours of high quality, four-channel digital cockpit audio and a minimum of 25 hours of digital flight data. Federal regulations do not require that the airplane be so equipped; however, based on positive experience with their commercial fleet, Embraer chose to install a CVDR on the EMB-500. Among the recorded flight data parameters are the aircraft's speed, altitude, engine power levels, attitude, heading, status of the anti-ice and deice systems, and the status of the autopilot and quick disconnect switch. For more information, see the Specialist's Flight Data Recorder Factual Report and Group Chairman's Cockpit Voice Recorder Factual Report in the docket for this accident, National Transportation Safety Board (NTSB) case number DCA15MA029, which can be accessed from the Accident Dockets link at www.ntsb.gov/air.

[2] According to the EMB-500 *Airplane Flight Manual*, pilots must activate the engine anti-ice system if the total air temperature is below 10º C with visible moisture (including clouds).

[3] The QRH was not among the documentation recovered from the wreckage but could have been destroyed in the postcrash fire.

systems. That action, in turn, would require the pilot to use landing distance performance data that take into account the deice system's activation.

CVDR data show that, before beginning the descent, the pilot set the landing reference (V_{ref}) speed at 92 knots, indicating that he used performance data for operation with the wing and horizontal stabilizer deice system turned off and an airplane landing weight less than the airplane's actual weight.[4] Using the appropriate Normal Icing Conditions checklist and accurate airplane weight, the pilot should have flown the approach at 126 knots (a V_{ref} of 121 knots +5 knots) to account for the icing conditions.

The NTSB's investigation found that the pilot's failure to use the wing and horizontal stabilizer deice system during the approach (even after acknowledging the right seat passenger's observation that it was snowing when the airplane was about 2.8 nautical miles from GAI) led to ice accumulation, an aerodynamic stall at a higher airspeed than would occur without ice accumulation, and the occurrence of the stall before the aural stall warning sounded or the stick pusher activated.[5] Because the deice system was not activated by the pilot before landing, the band indications (low speed awareness) on the airspeed display did not appropriately indicate the stall warning speed. The NTSB's aircraft performance study found that there would have been sufficient warning of an aerodynamic stall had the wing and horizontal stabilizer deice system been used during the approach.[6] Once the airplane stalled, its altitude was too low to recover.[7]

Based on available evidence, the NTSB could not determine why the pilot did not turn on the wing and horizontal stabilizer deice system during the approach to GAI. The pilot's EMB-500 instructors reported that use of both ice protection systems was covered during initial and recurrent training, and the pilot turned on both systems when he encountered conditions conducive to icing shortly after taking off on the accident flight. This information suggests that the pilot was informed about the criteria for using these systems. The NTSB considered several scenarios in evaluating the pilot's actions and identified the following areas for improvement to support safe operation of turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions, such as the EMB-500: [8]

- **Especially when conducting single-pilot operations, pilots of these airplanes would benefit from a system that provides automatic alerting when the ice protection systems should be activated.** Postaccident interviews with the pilot's

---

[4] For more information about the weight and balance for the accident airplane, see section 1.3.5.

[5] The stick pusher was not a recorded parameter of the CVDR and could not be heard on the CVDR recording; however, CVDR data show that the vane angle-of-attack (AOA) parameter reached or exceeded the stick pusher 28.4º AOA threshold three times during the last 20 seconds of flight.

[6] For more information, see the Aircraft Performance Study in the docket for this accident.

[7] According to the Federal Aviation Administration (FAA) Flight Standardization Board Report (FSB) for the EMB-500, which specifies training, checking, and currency requirements for EMB-500 pilots, the altitude lost during stall recovery will be 300 to 500 ft.

[8] Although airplanes like the EMB-500 are often referred to as "very light jets", or VLJs, there is no official definition of the features that characterize a VLJ. In this report, they are referred to as turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions, as these types of airplanes are generally more complex than piston-engine airplanes. In addition to the EMB-500, the Cessna Citation CE510 Mustang, HondaJet, and Eclipse 550 are currently in production.

first EMB-500 instructor revealed that the pilot had a tendency to freeze up and fixate on a subtask at the expense of other critical subtasks; thus, it is possible that the pilot forgot to activate the wing and horizontal stabilizer deice system during the approach (a relatively high workload phase of flight) to GAI. In a single-pilot operation, no additional crewmember is present to help detect an error of omission. Further, 14 *CFR* Part 91 operations do not necessarily share the same regulatory and organizational controls as 14 *CFR* Part 121 and Part 135 operations, which have more stringent requirements, oversight, and training that can all help to promote consistency in performance.

- **Pilots of these airplanes would benefit from training beyond what is required to pass a check ride.** Despite being described by his first EMB-500 instructor as very intelligent and highly motivated, the accident pilot needed a considerable amount of extra training time to prepare for his EMB-500 check ride. Although his instructors said that he was proficient by the time he passed his check ride and that all of the required special emphasis areas were addressed in some manner, evidence from the flight before the accident flight—as well as errors made by the pilot during the accident flight—revealed significant weaknesses in his capabilities.[9]

The NTSB determines that the probable cause of this accident was the pilot's conduct of an approach in structural icing conditions without turning on the airplane's wing and horizontal stabilizer deice system, leading to ice accumulation on those surfaces, and without using the appropriate landing performance speeds for the weather conditions and airplane weight, as indicated in the airplane's standard operating procedures, which together resulted in an aerodynamic stall at an altitude at which a recovery was not possible.

As a result of this investigation, the NTSB makes one safety recommendation each to the FAA, the General Aviation Manufacturers Association, and the National Business Aviation Association.

[9] Defined in the EMB-500 FSB, special emphasis areas are those that are "unique to the aircraft and should be given a higher degree of emphasis than regular training."

1 Factual Information

1.1 History of the Flight

On December 8, 2014, about 1041 eastern standard time, an Embraer EMB-500 airplane (marketed as the Phenom 100), N100EQ, registered to and operated by Sage Aviation LLC, crashed while on approach to runway 14 at Montgomery County Airpark (GAI), Gaithersburg, Maryland. The airplane impacted three houses and the ground about 3/4 mile from the approach end of the runway. A postcrash fire involving the airplane and one of the three houses, which contained three occupants, ensued. The pilot, the two passengers, and the three people in the house died as a result of the accident. The airplane was destroyed by impact forces and postcrash fire. The flight was operating on an instrument flight rules (IFR) flight plan under the provisions of 14 *Code of Federal Regulations (CFR)* Part 91. Visual meteorological conditions prevailed at the time of the accident.

On the morning of the accident, the pilot called a line service technician at Horace Williams Airport (IGX), Chapel Hill, North Carolina, and stated that he would be departing about 0930. When the pilot arrived at IGX, the line service technician helped the pilot pull the airplane from its hangar and service it with fuel. The line service technician reported that the pilot was "in a bit of a hurry" but did not appear to be careless. The pilot and the two passengers then boarded the airplane.

The pretakeoff checklists in the EMB-500 *Airplane Flight Manual* (AFM) include Airplane Power Up, Before Engine Start, Engine Start, After Engine Start (to be complete before taxi), and Before Takeoff. According to cockpit voice and data recorder (CVDR) information, the battery switch was turned on about 0939, and the first engine was started about 0940.[1] The Before Takeoff checklist indicated that the pilot was to check the airplane's takeoff configuration (flaps setting, brakes, and trim setting) by pressing the T/O CONFIG button on the center console, which prompts an aural annunciation stating "takeoff okay," provided that the flaps are properly set for takeoff, the parking brake is released, and the pitch trim setting is within the green band. However, the CVDR did not record the aural annunciation associated with completing that action. About 0945, the airplane accelerated for takeoff.

CVDR data indicated that the takeoff and cruise portions of the flight were uneventful and that the autopilot was activated about 0947. At 1000:16, the passenger in the right cockpit seat stated, "looks like we're in the clouds," to which the pilot replied, "yeah." CVDR data showed that the airplane's engine anti-ice system and the wing and horizontal stabilizer deice

[1] The airplane was equipped with a combination solid-state CVDR capable of recording 2 hours of high quality, four-channel digital cockpit audio and a minimum of 25 hours of digital flight data (federal regulations do not require that the airplane be so equipped). Among the recorded flight data parameters are the aircraft's speed, altitude, engine power levels, attitude, heading, status of the anti-ice and deice systems, and the status of the autopilot and quick disconnect switch. For more information, see the Specialist's Flight Data Recorder Factual Report and the Group Chairman's Cockpit Voice Recorder Factual Report in the docket for this accident, National Transportation Safety Board (NTSB) case number DCA15MA029, which can be accessed from the Accident Dockets link at www.ntsb.gov/air.

system were activated at 1000:32 and that the total air temperature (TAT) was -11º C.[2] They were turned off at 1002:55, while the airplane was at an altitude of 23,000 ft mean sea level (msl) and the TAT was about -10º C.[3] The CVDR recorded no activity or faults during the rest of the flight for either ice protection system. Between 1001:36 and 1007:17, the CVDR recorded three intermittent conversations between the pilot and the passenger in the right cockpit seat about a business meeting that they and the other passenger had planned to attend the next morning.

At 1008:45, a recording from the automated weather observing system (AWOS) at GAI began transmitting over the pilot's audio channel. The AWOS indicated the following conditions: wind from 070º at 2 knots, visibility more than 10 statute miles, few clouds at 2,300 ft above ground level (agl), overcast ceiling at 2,800 ft agl, temperature -1º C, and dew point -9º C.[4] Based on the AWOS, the AFM would require the ice protection systems to be turned on during the descent through the overcast layer.

According to the Descent checklist in the EMB-500 AFM, the pilot was to set the landing reference (V_{ref}), approach climb (V_{ac}), and final segment (V_{fs}) speeds before 10,000 ft. CVDR data showed that, at 1010:11, the pilot set a V_{ref} of 92 knots, a V_{ac} of 99 knots, and a V_{fs} of 119 knots. At 1011:56, the airplane began its descent from 23,000 ft.

At 1021:39, the pilot contacted the Potomac Terminal Radar Approach Control controller, who provided air traffic control services during the approach to GAI. The assigned sector controller provided the altimeter setting and asked the pilot to verify that he had received the current weather observation and to state the approach request. The pilot confirmed that he had the current weather observation and then requested the area navigation (RNAV) GPS RWY 14 approach to GAI.[5] After the airplane descended through a temperature inversion (in which the TAT climbed as high as 12º during the descent), the CVDR recorded the TAT below 10º C when the airplane was at an altitude of about 6,000 ft at 1023:00. At 1023:41, the airplane descended to 5,500 ft (an altitude at which pilot reports [PIREPs] indicated cloud tops) and the recorded TAT remained below 10º C.[6] At 1024:08, the recorded TAT was below 5º C at an altitude of about 5,000 ft. The TAT remained below 5º C for the duration of the flight.

At 1028:41, the CVDR began recording common traffic advisory frequency (CTAF) transmissions. At 1031:21, the controller instructed the pilot to cross the BEGKA intermediate fix (which was 11 nautical miles [nm] ahead) at 3,000 ft and cleared the airplane for the

---

[2] TAT is derived from the measurement of the free stream air temperature at the airplane's airspeed. Because of the fluid dynamic effects of airspeed on air temperature, TAT is warmer than the outside air temperature. In the EMB-500, pilots can monitor the TAT on a display that is located below and to the left of the primary flight display (PFD).

[3] All altitudes in this report are expressed as msl unless otherwise indicated.

[4] The AWOS recording continued until a frequency change at 1027:38 when the airplane was at an altitude of 5,000 ft and the TAT was about -2º C.

[5] RNAV approaches use ground-based and satellite-based systems to help pilots transition from the en route to the terminal environment. The RNAV GPS RWY 14 approach procedure to GAI includes several waypoints, or fixes, that guide pilots during the approach and descent to the airport.

[6] See section 1.4 for more information about the weather conditions during the airplane's approach to GAI.

approach to runway 14.[7] The pilot acknowledged the instruction and incorrectly read back the clearance, stating "BEGKA at one three thousand." At 1035:37, a pilot of an airplane on the ground at GAI asked on the CTAF whether "any precip [was occurring] out there." The accident pilot replied, "we're kind of in and out of the clouds here…at three thousand." About that time, the airplane's speed was 166 knots, and its vane angle-of-attack (AOA) was 0.8º.[8]

At 1035:41, the controller instructed the pilot to report the cancellation of the IFR clearance in the air on the assigned sector frequency or on the ground upon landing. The pilot was communicating with local traffic about the precipitation at that time, and the CVDR recording indicates that the controller's instructions were not audible in the pilot's headset.[9]

About 1036, the airplane intercepted BEGKA and turned onto the final approach course. At 1038:20, the controller asked the pilot, "[are] you still with me." The pilot responded, "sure are," and the controller then asked the pilot about his response to canceling the IFR clearance. At 1038:27, the pilot replied, "we're IMC [instrument meteorological conditions] at the moment but…we should be clear in just a minute or two. We'll let you know." At that time, the airplane was at an altitude of about 2,700 ft. The controller then approved the change to the CTAF and reminded the pilot to cancel the clearance. The pilot's acknowledgment of this information was the last recorded radio transmission from the airplane to the controller.

At 1039:07, when the airplane was 5.5 nm from the runway, the pilot reported on the CTAF that the airplane was "now at 7 miles straight in for [runway] one four." The airspeed was 140 knots about this time. At 1039:15, the pilot selected a flaps 3 setting (26º). The airspeed began to slowly decrease. Starting at 1039:22, the pilot said to the passenger in the right cockpit seat, "so your job is to find the airport…just look straight ahead and say airport in sight." At 1040:03, the front right seat passenger stated, "snow," and the pilot responded, "wow, there's snow."[10] At 1040:34, the airplane was 2.8 nm from the runway at 1,450 ft msl, and the right seat passenger told the pilot that he had visually located the airport. Three seconds later, the pilot confirmed that the airport was straight ahead, and immediately after that, the airplane's flaps were moved to their fully extended position (36º). At 1040:45, the airplane was 2.5 nm from the runway, and the pilot transmitted on the CTAF that the airplane was 3 miles out from runway 14.

At 1041:12, the airplane's airspeed decreased below 115 knots. The airspeed continued to decrease as the autopilot slowly pitched the airplane up to maintain the RNAV glidepath. At 1041:24, the airplane's pitch was 3º, and the AOA was 10º. By 1041:31, the pitch was 7º, the AOA was 16º, and airspeed had decreased to 92 knots. At 1041:33, the pilot increased the engine fan speed, which stopped the deceleration for a few seconds; however, as the pitch and AOA continued to increase, the airspeed resumed its downward trend.

---

[7] An intermediate approach fix is the start of the intermediate approach segment, which positions an aircraft for the final descent to the airport. BEGKA is the name of that approach fix.

[8] The AOA sensors, which are mounted on each side of the forward fuselage, have vanes that measure the direction of local airflow. All AOAs in this report refer to vane-derived measurements unless otherwise indicated.

[9] It is likely that the transmission was not broadcast in the pilot's headset because he had either temporarily de-selected the radio that was tuned to the approach frequency or turned down its volume.

[10] From 1039:50 to 1040:39, the CVDR recorded the onset of a static-like background noise.

CVDR data showed that, at 1041:33, with the autopilot engaged, the airplane began to roll to the right, reaching a bank angle of about 21º at 1041:35 before starting to roll to the left. At that time, the airplane was at an altitude of about 840 ft (300 ft above field elevation) and about 1 mile from the runway. Also at that time, the airplane's vertical acceleration decreased from 0.96 to 0.74 G. At 1041:35.9, the airplane's stall warning annunciation sounded. At that time, the airplane's airspeed was 88 knots, and the AOA was 21º. CVDR data showed that the autopilot disengaged at 1041:35.8.

Between 1041:35.9 and the end of the flight, the CVDR recorded the aural stall warning annunciation numerous times. The engine fan speed increased from 67% at the time of the first aural stall warning to 86% (the takeoff/go-around detent) at 1041:39, where it remained for the rest of the flight. Aside from the change in thrust, the pilot's control inputs in response to the aural stall warnings could not be determined.[11] The airplane pitched 4º nose down after the first stall warning before pitch returned to level and then began oscillating between positive and negative pitch attitudes.

At 1041:37.7, the airplane rolled about 59º to the left and then went through several roll oscillations before returning to wings level and then starting another roll to the right. The airplane rolled to 100º right at 1041:52.4 and continued to roll to the right to about 154.5º at 1041:54.7. The stick pusher was not a recorded CVDR parameter and could not be identified on the CVDR, but the vane AOA parameter reached or exceeded the stick pusher 28.4º AOA threshold three times during the last 20 seconds of flight.

At 1041:55.4, the CVDR recorded a sound similar to impact, and the recording ended immediately afterward. The airplane impacted three houses and terrain in a left-wing-down attitude of 110.5º about 4,000 ft from the approach end of runway 14. The location of the main wreckage was about 900 ft left of the extended runway centerline.

Witness Statements

The NTSB interviewed two certificated flight instructors who witnessed the accident. One of the witnesses (on the ground at GAI) stated that he heard the accident pilot make position reports when the airplane was 7, 5, and 3 miles from the runway. At the time of the pilot's 3-mile position report, the witness saw the airplane emerge from the clouds with its landing lights on. Afterward, he saw the airplane in "what looked like an uncontrolled S-turn," and then he saw the airplane roll in the opposite direction and disappear behind trees. The witness thought that the airplane might have been flying too slowly.

Another witness (in the air) reported that he heard the accident pilot make a 10-mile position report. The witness stated that he first saw the accident airplane on short final approach with its landing lights on. At the time, he thought the airplane was making uncontrolled S-turns and appeared to be "pretty low." He reported seeing the airplane banking to the left, right, and left again, at which time it became inverted and impacted the ground.

[11] Control input and control surface positions are not among the parameters recorded by the CVDR.

The witnesses estimated that the cloud ceiling was between 1,500 and 2,000 ft with visibility between 4 and 7 miles. The witness in the air and a third flight instructor who had been flying locally just before the accident reported no turbulence.

1.2 Personnel Information

The pilot, age 66, held a Federal Aviation Administration (FAA) airline transport pilot certificate with airplane single- and multiengine land ratings. He received a type rating for the EMB-500 airplane on April 28, 2014, and had a letter of authorization to operate the Aero Vodochody L-39 airplane. The pilot also held a flight instructor certificate with a rating for single-engine airplanes. The pilot held a second-class medical certificate, dated February 7, 2014, with the limitation that he must wear corrective lenses.

FAA records indicated that the pilot was involved in a March 2010 nonfatal accident at GAI in which the Socata TBM-700 airplane he was operating traveled about 100 ft off the left side of the runway during an attempted go-around. The NTSB's investigation found that the probable cause of the accident was "the pilot's failure to maintain aircraft control while performing a go-around."[12] As a result of the accident, the FAA conducted a reexamination of the pilot on August 19, 2010, which the pilot passed successfully. The reexamination consisted of a 1-hour oral examination and a 1-hour flight examination, which included instrument landing system approaches, missed approaches, go-arounds, balked landings, and landings. FAA records also indicated that the pilot received an enforcement action for violating a temporary flight restriction on August 18, 2011.

A review of the pilot's electronic logbook showed that he had accumulated a total of about 4,737 hours of flight experience as of November 20, 2014 (the last entry). The logbook indicated that this flight time included about 1,500 hours in Socata TBM-700 airplanes, 60 hours in Aero Vodochody L-39C airplanes, and about 136 hours in the Embraer EMB-500 accident airplane. He flew about 14.6 hours during the 2 months before the accident. His last recurrent training on the EMB-500 occurred on September 26, 2014.

According to his wife, the pilot was a physician and the chief executive officer of a clinical research company that he founded in 1989, which was headquartered in Chapel Hill. The pilot's wife stated that the pilot normally worked in his company office from 0730 to 1800 Monday through Friday and that he worked similar hours during the weekends but did not usually go into the office. The pilot maintained homes in Chapel Hill and at a fly-in community in Port Orange, Florida. A check of the National Driver Registry and driving records for the states of Florida, North Carolina, and Maryland revealed no evidence of license suspension or revocation or driving-related offenses.

The NTSB reviewed the pilot's activities in the 72 hours before the accident, as described by his wife. Each day the pilot woke between 0600 and 0700 and went to sleep between 2200 and 2300, a sleep schedule that the pilot, according to his wife, had maintained "for years." On

[12] More information about this accident, NTSB case number ERA10CA155, can be found by accessing the Aviation Accident Database link at www.ntsb.gov/air.

December 5, 2014, the pilot worked at his office. During the weekend of December 6 and 7, the pilot exercised, worked at home during the day, and engaged in routine activities both nights before going to sleep. On December 8, the pilot woke between 0600 and 0615. His wife stated that, between the night of December 5 and the morning of December 8, the pilot reported no difficulty sleeping. The pilot left home a little “earlier than normal” because he was going to be flying that morning. She stated that he seemed to be in a good mood and cheerful. He spoke with a family member who lived in the Washington, DC, area and made plans to meet for dinner that evening. The pilot’s plans in the afternoon on the day of the accident are unknown.

The pilot’s wife stated that, during the 12 months before the accident, no significant changes had occurred regarding the pilot’s finances, personal life, or health. She described the pilot as “very healthy” and stated that she did not know of any ongoing medical conditions affecting the pilot. She also was not aware of any prescription or nonprescription medications that the pilot might have taken in the 72 hours before the accident that could have affected his performance during the flight. She further stated that he did not experience any illnesses, such as a cold or flu, in the days before the accident.

1.2.1 The Pilot’s EMB-500 Training

The pilot received training in the accident airplane from several different sources. He received training from a qualified instructor at Kenmore Crew Leasing Inc., dba Holland Aviation (a company that provides transition and recurrent training in the EMB-500), between March 27 and April 3, 2014 (about 21 hours of flight instruction). From April 11 to 24, 2014 (about 25 hours of instruction), the pilot received training from a qualified instructor in Chapel Hill in preparation for his check ride to receive a type rating in the EMB-500. About 5 months after completing the check ride, the pilot received recurrent training from the check ride examiner, which (as previously stated) he completed on September 26, 2014.

The company instructor who initially conducted the pilot’s transition training in the EMB-500 characterized the pilot as highly motivated, very intelligent, and possessing a strong aptitude for memorization. He stated, however, that the pilot had difficulty with planning and workload management and sometimes became “task saturated,” freezing up or fixating on a subtask at the expense of other critical subtasks. He said that, as a result, the pilot’s training progress was slow.

This instructor also stated that because the pilot was highly intelligent and accomplished in other areas of his life, he seemed to overestimate his own ability and underestimate certain aviation-related risks. For example, he said that the pilot had requested an abbreviated training course although he did not have sufficient aviation experience to become proficient in the airplane through an abbreviated course. The pilot accepted the instructor’s recommendation to take the full course. However, after the pilot completed the course, the instructor did not believe that he met the required standards to obtain a type rating in the EMB-500 and advised the pilot to receive more training.

The pilot contacted an instructor in Chapel Hill who provided about 24 hours of additional flight instruction with about 1 hour of ground instruction before each flight. This instructor and the check ride examiner, who also subsequently provided recurrent training to the pilot, said that the pilot had been trained to proficiency. Neither expressed any concerns about the pilot's flying or decision-making skills.

The company instructor and the check ride examiner reported that icing procedures were covered in the pilot's initial and recurrent training. The first instructor stated that his instruction covered these procedures in two parts: operations limitations/normal operations and performance limitations, per the AFM. He stated that he trained his students to monitor the air temperature on the PFD, per the AFM, rather than look for ice on the airframe. He and the pilot encountered icing conditions during training (most of which was conducted in IFR), and all of these operations were conducted with the ice protection systems turned on. He also stated that he discussed with the pilot that the EMB-500's operation in icing conditions generally limited the airplane to runways of 5,000 ft or longer.[13]

The pilot's check ride examiner said that the topics of ice recognition and how to use the deice boots were covered during the oral portion of the pilot's examination. The oral portion of the pilot's examination also included—as a special emphasis item—knowing that the activation speed for the stall warning and the stick pusher increased when the wing and horizontal stabilizer deice system is activated.[14]

1.2.2 The Pilot's Performance During the Flight Before the Accident Flight

The airplane's CVDR contained data for the flight before the accident flight that showed that the pilot had problems managing altitude during his arrival into the Chapel Hill area. He first flew over the airport at 5,400 ft agl, then circled around to lose altitude, descended to 1,000 ft agl 9 nm from the runway on an extended straight-in approach, and then climbed to 1,500 ft agl before descending to the runway. The pilot also attempted to set flaps 2 on final without lowering the gear (which was out of sequence) and received a "landing gear" aural warning as a result.

1.3 Aircraft Information

According to the FAA's Flight Standardization Board (FSB) report for the EMB-500, dated September 15, 2010, the EMB-500 is a low-wing, T-tail airplane powered by two high-bypass-ratio, rear-mounted turbofan engines (FSB 2010). The airplane has a fully retractable tricycle landing gear, a glass cockpit panel with "highly integrated onboard avionics," and two cockpit seats and four cabin seats in a "club seating" configuration. The airplane is certified for flight in known icing conditions. The type certificate for the airplane was approved in December 2008.

The accident airplane was manufactured in October 2009, and the FAA issued its standard airworthiness certificate in November 2009. The airplane's logbook was destroyed in the accident, but two separate sources provided information regarding the airplane's total number of flight hours and flight cycles. According to Embraer, the owner reported on October 7, 2014,

[13] As discussed in section 1.5, the runway at GAI is 4,202 ft long.

[14] See section 1.11.4 for additional information about special emphasis areas for the EMB-500.

that the airplane had accumulated 633 flight hours and 551 flight cycles. The work order records from the contract maintenance provider for Sage Aviation indicated that, at the time of the airplane's last maintenance and inspection on November 13, 2014, the airplane had accumulated 634 flight hours and 552 flight cycles.

The airplane was powered by two Pratt & Whitney Canada PW617F-E turbofan engines, each of which had a maximum thrust rating of 1,820 lbs. According to records for the airplane's last maintenance and inspection on November 13, 2014, each engine had accumulated 634 hours since new and 552 cycles since new.

The airplane was maintained in accordance with Embraer's scheduled maintenance requirements, as defined in the company's aircraft maintenance manual. The engines were maintained in accordance with Pratt & Whitney Canada's recommended maintenance requirements. The work order records from the contract maintenance provider for Sage Aviation indicated that, during the November 2014 maintenance and inspection, regularly scheduled maintenance was performed, and no discrepancies were found for the stall warning and protection system (SWPS), the flap control system, and other avionics.

The FSB report for the EMB-500 also stated that "the EMB-500 has no unusual stall characteristics if stall recovery is initiated at the first indication of a stall, which is well above an aerodynamic stall." However, the report notes that the stall characteristics were such that a stick pusher was required to mitigate these characteristics. The report further stated the following: "An aerodynamic stall occurs at the same approximate airspeed as stick pusher activation. If the stick pusher activates, the loss of altitude during the stall recovery will be 300 to 500 feet."

1.3.1 Stall Warning and Protection System

The EMB-500 SWPS provides pilots situation awareness with an aural warning that annunciates "STALL" and a stick pusher that activates for protection if the airplane is approaching a stall condition. The primary SWPS components are the AOA sensors, the SWPS computer, and the stick pusher actuator.[15] Mounted on each side of the forward fuselage, AOA sensors have vanes that measure the direction of local airflow. The SWPS computer receives information from independent resolvers (two for each AOA sensor) about their respective AOA. The computer monitors this information and provides the pilot an aural warning, a visual indication of low speed on the airspeed tape on both PFDs, and/or activates the stick pusher actuator.

To prevent the airplane from entering a potentially hazardous stall condition, activation of the stick pusher causes the control column to move forward with about 150 lbs force to deflect the elevator to 9º ± 1º trailing edge down, which reduces the AOA and increases airspeed. Pilots can move the control column farther forward to increase elevator deflection. With the landing gear extended, flaps fully deployed, and the wing and horizontal stabilizer deice system not activated (as the accident airplane was configured), the EMB-500 aural stall warning is designed to sound at 21º AOA. In this configuration, the stick pusher is designed to activate at 28.4º AOA.

[15] The stick pusher actuator is a rotary electromechanical actuator connected to the elevator control system.

With the same configuration but with the deice system activated, the initial stall warning would sound at 9.5º AOA, and the stick pusher would activate at 15.5º AOA.

1.3.2 Autopilot System

The EMB-500 autopilot comprises two Garmin integrated avionics units that receive inputs from a guidance panel, air data computers, the attitude and heading reference system, and other discrete inputs. The autopilot is designed to disengage if a stall warning signal is received from the SWPS computer.

1.3.3 Anti-Ice and Deice Systems

The airplane was equipped with engine anti-ice and wing and horizontal stabilizer deice systems that are controlled by ON/OFF switches (labeled ENG 1, ENG 2, and WINGSTAB) on the ice protection/heating control panel located at the bottom of the main panel on the left side of the cockpit (figure 1 shows a diagram of the ice protection/heating control panel).[16] As an indicator pilots use to determine when the ice protection systems should be activated, the TAT display is located below and to the left of the PFD (see figure 2).

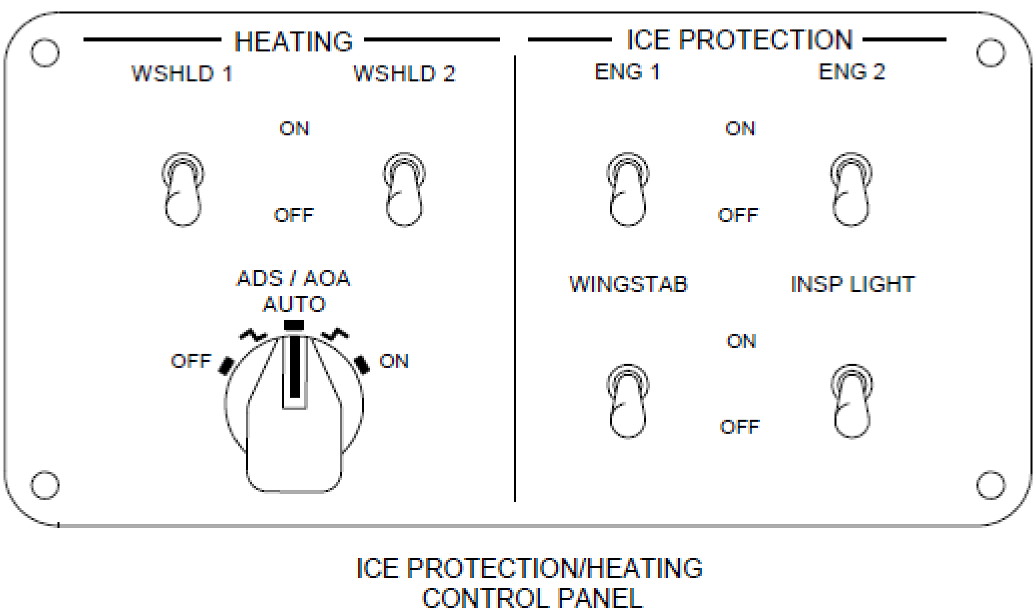

Figure 1. Diagram showing the EMB-500 ice protection/heating control panel.

[16] The engine anti-ice system prevents ice formation, and the wing and horizontal stabilizer deice system removes ice after it has formed.

Figure 2. The TAT display (circled in red) as shown to EMB-500 pilots in normal operation.

Once activated, the engine anti-ice system uses hot bleed air from the engine compressors to remove or prevent ice formation around the engine inlet cowls and operates continuously. The wing and horizontal stabilizer deice system automatically cycles deice boots every minute when the WINGSTAB switch is set to ON. Each wing has two deice boots (one mounted on the wing outboard section and the other mounted on the wing inboard section), and each horizontal stabilizer has a single deice boot on the leading edge. The deice boots are pneumatically inflated for 6 seconds each (for a 1-minute cycle) using bleed air from the engines and are then deflated to mechanically remove ice that has formed on the leading edges. The boots are inflated in the following sequence: horizontal stabilizer, outboard wing, and inboard wing. If the system remains activated, the inflation cycle begins again. The EMB-500 is not equipped with an ice detection system.

1.3.4 Low Airspeed Awareness Tape

The airspeed tape on the PFD provides pilots with low-airspeed awareness indicators consisting of a short yellow band positioned above a longer red band and a green circle on the right edge of the tape (see figure 3). The top of the red band denotes the airspeed for the activation of the aural stall warning, the top of the yellow band marks an airspeed that is 3 knots faster than the onset of the aural stall warning, and the green circle denotes 1.3 times the speed at which the stick pusher would activate. Activating the airplane's wing and horizontal stabilizer deice system results in a lower AOA threshold to trigger the SWPS and, therefore, higher indicated airspeeds for the warning bands on the airspeed tape display (see figure 4).

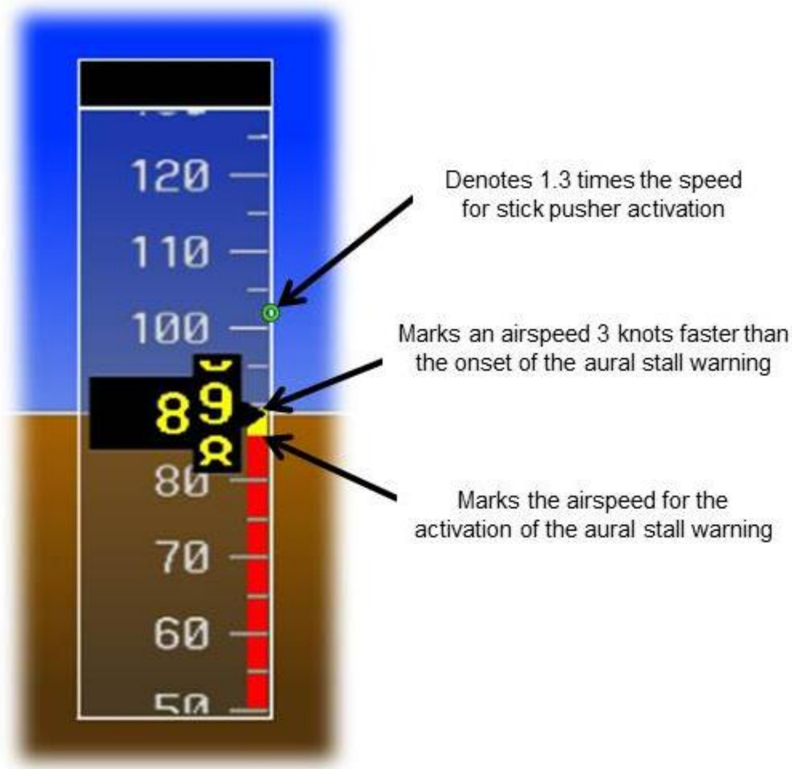

Figure 3. Simulated EMB-500 airspeed tape display (with ice protection deactivated).

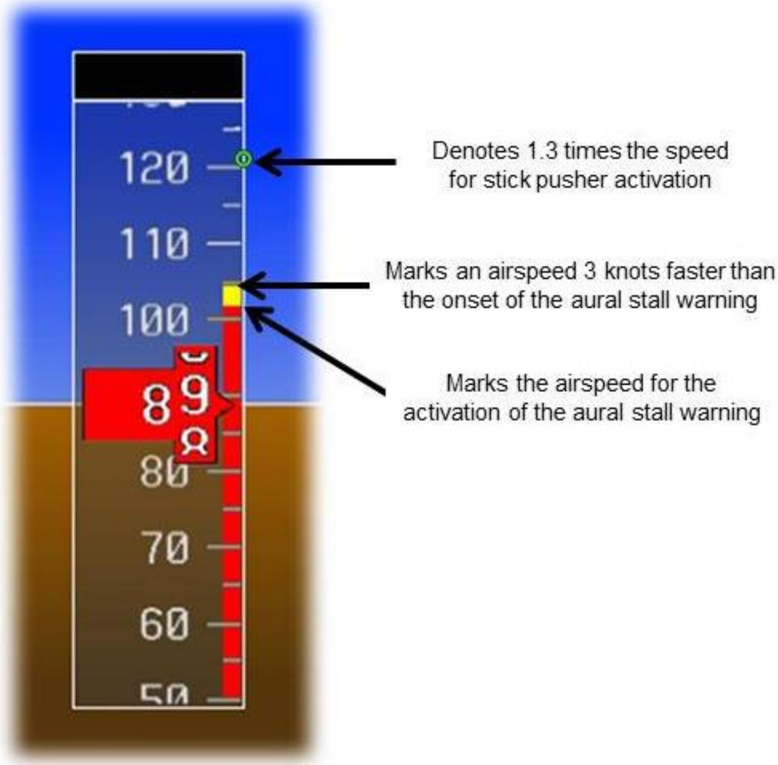

Figure 4. Simulated EMB-500 airspeed tape display (with ice protection activated).

1.3.5 Weight and Balance

No documentation or other evidence of the pilot's weight and balance calculations for the accident flight were found. A weight and balance report (dated October 3, 2009) found in the wreckage showed the airplane's basic empty weight as 6,944 lbs. According to the CVDR, the fuel weight at the end of the approach was 1,036 lbs. Using the weight and balance report, pilot and passenger weights obtained from postmortem examination (661 lbs), the actual weights of items found within the wreckage (30 lbs), and the fuel weight, the NTSB calculated the airplane's landing weight and center of gravity at 8,671 lbs and 28.197% mean aerodynamic chord, which are within the limits specified in the AFM. The CVDR-recorded landing weight, which is based on the airplane's basic empty weight, fuel load, and pilot inputs for occupant and cargo weights, was 8,277 lbs.

1.3.6 Performance Calculations

The NTSB performed the landing distance calculations for the accident flight using the EMB-500 *Pilot Operating Handbook* (POH), the *Quick Reference Handbook* (QRH), and the airplane's optimized performance analyzer (OPERA) software.[17] Among the inputs used in the

[17] OPERA is a computer-based flight planning program developed by Embraer and distributed to airplane owners. The program is an FAA-approved source of performance information for the EMB-500.

software were the NTSB-calculated weight and balance data, weather information, ice protection system status, and GAI runway information.

With the ice protection systems selected to OFF, the OPERA-generated information for full flaps and a landing weight of 8,700 lbs (rounded from 8,671 lbs) returned a V_{ref} of 95 knots and a runway length requirement of about 2,300 ft. For the same flap configuration and landing weight but with the ice protection systems selected to ON, the OPERA result indicated "NO OPERATION," meaning that with these parameters, the airplane's climb performance would be insufficient in the event of a go-around with only one engine.

The pilot's first instructor in the EMB-500 stated that the pilot used a tablet application called myPhenom Flight Calculator to do his performance calculations and confirmed the numbers by referring to his QRH. Developed by the Embraer Jet Operators Association, the application uses data from the POH, according to information on the association's website.[18] Investigators were unable to locate the pilot's tablet or a copy of the QRH in the airplane wreckage, but a copy of the POH and AFM were found. Investigators also found a laminated abbreviated checklist that did not include any icing-related checklists or performance data. The NTSB could not determine which of these sources the pilot used to enter the landing speeds for the accident flight.

1.3.7 EMB-500 Flight Manuals

The Normal Icing Conditions checklist in the EMB-500 QRH and the Normal Procedures section of the AFM indicate that, during the descent and approach phases of flight, pilots are to verify whether icing conditions exist. If the TAT is below 10º C with visible moisture during the after takeoff, cruise, descent, or approach phases of flight, pilots must activate the ENG 1 and ENG 2 switches. At the first sign of ice accretion on the airplane or if the TAT is below 5º C with visible moisture, pilots must activate the ENG 1, ENG 2, and WINGSTAB switches.

The Limitations section of the AFM, under the heading "Operation in Icing Conditions," states the following: "Icing conditions may exist whenever the…TAT in flight is 10ºC or below and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet, and ice crystals)." This section of the AFM also states that the autopilot could mask tactile cues that indicate adverse changes in handling characteristics and that the pilot should consider not using the autopilot when any ice is visible on the airplane.

Performance data in the QRH show that, in the accident airplane's configuration (wing and horizontal stabilizer deice system selected to OFF and full flaps) and landing weight of 8,700 lbs, the V_{ref} is 95 knots, and a landing distance of 2,524 ft is required. In the same configuration with a landing weight of 8,300 lbs (rounded up from the weight recorded by the CVDR), performance data in the QRH indicate a V_{ref} of 92 knots and a required landing distance of 2,441 ft. With full flaps and the deice system selected to ON for both landing weights, QRH performance data show that the limitations for the airplane's climb performance are exceeded in the event of a go-around with only one engine.

[18] More information about this application can be found online at https://www.phenom.aero/resources/myPhenom/.

Performance data in the QRH also show that in icing conditions, considering the aircraft landing weight for the accident flight, the airplane should be configured with a flaps 3 setting rather than with full flaps. With the flaps 3 setting, a landing weight of 8,700 lbs, the engine anti-ice and wing and horizontal stabilizer deice systems selected to ON, and no wind, the V_{ref} is 121 knots, and the landing distance is 4,117 ft. In addition, the QRH Normal checklist for operation in icing conditions indicates that, during the approach, the airplane should be operated at 5 knots higher than V_{ref}; thus, the minimum approach speed for the accident approach should have been 126 knots.

1.4 Meteorological Information

GAI's AWOS, the closest official National Weather Service (NWS) reporting location to the accident site, is privately owned and operated. The AWOS, located near midfield and immediately east of runway 14, issues observations from the ground every 20 minutes and broadcasts current conditions that are updated at least once per minute. The AWOS weather observation at 1035 (about 6 minutes before the accident) indicated the following: wind from 040º at 6 knots, visibility 10 statute miles, a few clouds at 2,100 ft agl, ceiling overcast at 3,200 ft agl, temperature -1º C, dew point temperature -7º C, altimeter 30.61 inches of mercury. The AWOS did not have a precipitation discriminator and therefore could not report types of precipitation. An NWS national radar mosaic for 1040 depicted several bands of very light intensity echoes over the area, likely associated with snow showers and/or snow squalls. A base reflectivity elevation scan completed at 1041:52 also depicted several bands of very light intensity echoes associated with light precipitation or snow that extended over the airplane's flight track during the descent and approach to GAI (shown as a black line in figure 5).

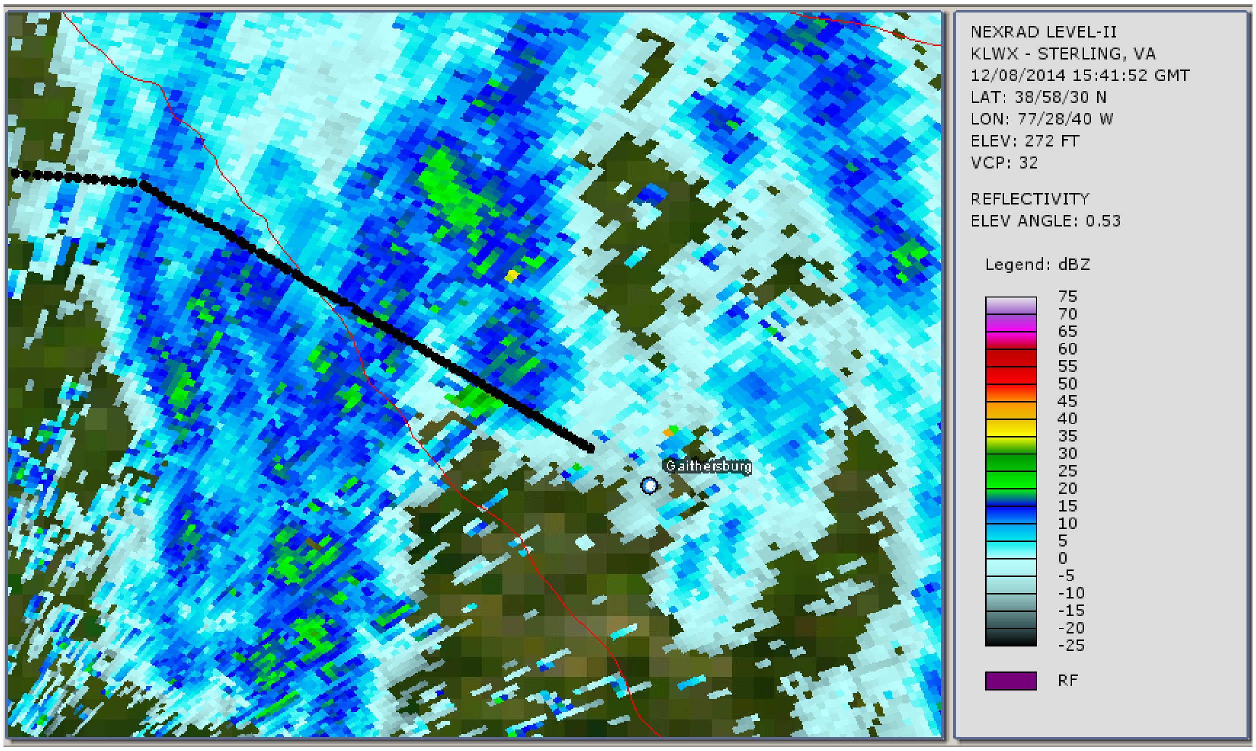

Figure 5. A Weather Surveillance Radar 88 Doppler base reflectivity scan with the accident airplane's flight track in black overlaid.

A line service technician at IGX who interacted with the pilot on the morning of the accident did not know whether the pilot had obtained a preflight weather briefing while at the airport. The technician stated that the airport did not have a computer and that most of the pilots used their own resources to obtain this weather information. (Three laptop computers and the pilot's cell phone were recovered in the wreckage; damage to the laptops precluded recovery of pertinent data, and data recovered from the cell phone did not include weather information.) No evidence indicated that the pilot had obtained a preflight weather briefing from an FAA-contracted automated flight service station (AFSS) or a direct user access terminal system (DUATS) provider. No NWS advisories or forecasts before the flight departed would have restricted the flight from operating, and no alternate airport was required for the flight.

About 17 PIREPs were issued between 0845 and 1045 for conditions over the Washington, DC, area on the day of the accident.[19] About one-third of these PIREPs indicated structural icing conditions between 2,500 and 5,300 ft. Most of these PIREPs reported light rime-type icing.[20] Multiple air carrier jet airplanes flying over the vicinity of the accident site reported icing conditions in the clouds, with cloud tops from 4,300 to 5,500 ft. A PIREP at 0845 near GAI indicated light clear-type icing at 4,000 ft and a temperature of -3º C. At 1045 (about 4 minutes after the accident), a pilot of an air carrier turboprop airplane immediately northwest

[19] The NTSB's investigation could not determine whether the pilot reviewed any of these PIREPs before departure.

[20] Rime ice is an opaque, granular, and rough deposit of ice that can form on the airplane's surfaces, including, in part, the wing leading edges, the horizontal stabilizers, and the engine inlets.

of the accident site reported encountering moderate mixed icing conditions between 4,000 and 5,000 ft and a temperature of -7º C at 4,000 ft.

1.5 Airport Information

GAI is an uncontrolled (nontowered) airport located about 3 miles northeast of the city of Gaithersburg, Maryland, and 17 miles from Washington, DC. The airport, which opened in 1959, has a field elevation of 539 ft. The airport has one asphalt runway, 14/32, that is 4,202 ft long and 75 ft wide. Runway 14 has an upsloping runway gradient of 1%. Three instrument approach procedures are listed for the airport, including the RNAV (GPS) RWY 14 approach.

1.6 Flight Recorder

The airplane was equipped with an L-3/Fairchild FA2100-3083 combination solid-state CVDR, serial number 600192. Federal regulations do not require the airplane to be so equipped; however, based on positive experience with their commercial fleet, Embraer chose to install a CVDR on the EMB-500.[21] The CVDR recorded 2 hours 4 minutes of excellent-quality digital cockpit audio, which included audio from a previous flight on November 24, 2014. The CVDR audio for the accident flight began at 0939:03 and ended at 1041:56. The CVDR was designed to record a minimum of 25 hours of digital flight data. It recorded 178 hours of data, about 1 hour 2 minutes of which were for the accident flight. The appendix at the end of this report contains a partial transcript of the CVDR audio.

1.7 Wreckage and Impact Information

Portions of all major airplane components were found at the accident site. These components showed no evidence of any structural, engine, or system failures.

The airplane’s initial impacts occurred when its right wing struck tree branches above a house (referred to as house A in this report). The left wing struck the roof of the house and then an interior second-story bedroom wall. The left wing tip then struck the ground in the front yard of house A. The evidence was consistent with an impact attitude of about -30º (nose down) and -110.5º (left wing down).

The airplane’s nose struck a tree in the yard of a second house (referred to as house B in this report), causing fragmentation of the nose along a debris trail and heavy damage to the tree. The airplane had traveled on a 107º magnetic heading from its initial impact point to the tree. The top of the horizontal stabilizer then struck house B near a second-story window to the left of the front door. Part of the vertical stabilizer, the horizontal stabilizer, and the right elevator were found at the front door of house B. A large impact hole, with a diameter similar to that of the fuselage, was found near the base of the heavily damaged tree, with the left elevator at the far end of the impact hole.

---

[21] Title 14 *CFR* section 91.609, “Flight data recorders and cockpit voice recorders,” outlines the requirements of recorder equipage for Part 91 operations.

The fuselage was found on a 287º magnetic heading on the driveway of house B, facing the direction it came from. The portion with the cockpit came to rest in an inverted position, with heavy impact damage to the top half of the cockpit (see figure 6); the portion from the cabin door aft was found on its right side, and the cabin was consumed by fire. Damage to the ice protection/heating control panel was extensive, and it was not possible to visually determine the positions of the anti-ice or deice switches. The wing attach fittings on the center section of the fuselage were bent and broken, with both left fittings displaced aft and both right fittings displaced forward. The right wing leading edge was found in two segments on the driveway. Leading edge fragments from the left wing were found in the yard of house B. The tailcone and the left engine were located to the right of the house B driveway.

Figure 6. Photograph of the fuselage showing impact and fire damage to house B.

Most of the wing structure was found inside and in front of a third house (referred to as house C in this report). After impact, a postcrash fire at house C ensued. The remnants of the wing were found resting with their top surfaces upward. The wing center section had been consumed by fire. The right wing tip was found in the front yard. The main landing gear was found extended in the debris in front of the house. The right engine was found in the backyard of house C with fuel burn in the grass directly beside the engine.

The examination of both engines found no evidence of an engine case breach, a catastrophic engine failure, or an in-flight fire. The right engine exhibited fire damage to the underside of the engine cowl near fractured fluid tubes, which was consistent with a postcrash fire. Neither engine exhibited evidence of any significant fan impact or ingestion damage or pre- or postcrash foreign object ingestion.

1.8 Medical and Pathological Information

According to the pilot's autopsy report from the Office of the Chief Medical Examiner for the State of Maryland, the pilot's cause of death was multiple injuries, and the manner of death was an accident. The toxicology report from the FAA's Civil Aerospace Medical Institute's Bioaeronautical Sciences Research Laboratory in Oklahoma City, Oklahoma, showed atorvastatin (a lipid-lowering medication) in the pilot's liver specimen. According to the report, no ethanol or other tested drugs were detected in the pilot's specimens.

The cause of death for both passengers was multiple injuries. The three people who were in house C at the time of the accident died from smoke inhalation. After the airplane's wing struck the house, the damage and ensuing fire trapped the occupants on the upper floor.

1.9 Tests and Research

1.9.1 Duration of EMB-500 Pretakeoff Procedures

NTSB investigators visited the Embraer CAE Training Services (ECTS) facility in Dallas, Texas, and conducted test flights in an EMB-500 simulator.[22] During these simulations, the power up, before engine start, engine start, and after engine start procedures were performed to completion and timed. Investigators found that systematic completion of all tasks took about 9 minutes, as shown below.

Procedures	Duration
Power Up and Before Start	4:35
Starting Engines	1:52
After Start	2:52
Total	**9:19**

1.9.2 Aircraft Performance Study

An aircraft performance study was performed for this accident to determine, among other things, whether structural icing might have played a role in the circumstances leading to the accident. As part of this work, the accident airplane's flight track was combined with the weather radar echoes surrounding the time of the accident. The results showed that the airplane was in IMC until about 5 miles from GAI and flew in and out of the clouds from that point.

The recorded data showed that roll oscillations began and an aerodynamic stall occurred shortly before the aural stall warning at 1041:35.9, providing the pilot with no warning of the

[22] ECTS is a joint venture between Embraer and CAE.

impending stall. According to Embraer, with the airplane configured with the gear down, full flaps, and the wing and horizontal stabilizer deice system activated, the stall warning would sound at an AOA of 9.5º (instead of 21º, as occurred in the accident sequence). Embraer's data also showed that, if a stall were to occur with the gear down, full flaps, and the deice system activated, the stick pusher would activate at an AOA of 15.5º instead of 28.4º.

The aircraft performance study included a comparison of the recorded data for the accident flight (without the wing and horizontal stabilizer deice system activated) and the AOA thresholds when the deice system is selected. These data indicated that if the AOA thresholds with the deice system selected were applied to the approach to GAI, the stall warning threshold would have been exceeded about 20 seconds earlier when the airplane was at an estimated altitude of 1,000 ft agl and 10 knots faster than it was in the accident sequence. The comparison shows that activating the deice system would have provided the pilot with substantial advance warning time and more altitude and airspeed to deal with an aerodynamic stall.

The aircraft performance study also included simulations of the low-airspeed awareness cues on the airspeed tape. According to the simulations, because the pilot had not activated the wing and horizontal stabilizer deice system during the approach to GAI, the airspeed tape would have shown, just before the stall warning sounded, the top of the red band at 87 knots, the top of the yellow band at 90 knots, and the green circle at 102 knots (see figure 3). The simulations showed that, if the deice system had been activated, the airspeed tape would have displayed the top of the red band at 102 knots, the top of the yellow band at 105 knots, and the green circle at 121 knots (see figure 4).

1.10 Organizational and Management Information

The accident airplane was registered to Sage Aviation LLC of Chapel Hill, North Carolina; the accident pilot was the company's principal officer. The corporation purchased the accident airplane on March 26, 2014, from its former owner for personal and business purposes. The FAA issued a new certificate of registration on April 23, 2014.

Embraer was founded in August 1969 with the formal name Empresa Brasileira de Aeronáutica S.A., which was changed to Embraer S.A. in November 2010. Embraer is headquartered in São José dos Campos, Brazil.[23]

1.11 Additional Information

1.11.1 The EMB-500 and Other Single-Pilot Jets

Turbofan airplanes that require a type rating and are certified for single-pilot operation and flight in icing conditions, such as the EMB-500, were designed to take advantage of the latest advances in cockpit avionics and automation, reduce pilot workload, and allow operation

[23] More information can be found on Embraer's website at www.embraer.com.

by a single pilot, typically with a manufacturer-suggested retail price under about $4.5 million.[24] They were also intended to be capable, high-altitude IFR cruising airplanes. The desire for high-altitude, all-weather capability for these airplanes prompted the installation of ice protection systems, which, due to their general use of deice boots on wing and horizontal stabilizer surfaces, are similar to those of turboprops.

1.11.2 Icing Certification

FAA certification standards require manufacturers to determine the amount of ice that may form on critical surfaces, such as before or between deice boot activations in maximum icing conditions specified in 14 *CFR* Part 23 Appendix C. Manufacturers are required to study the effect of this ice accumulation on performance and show that with use of the ice protection system, the airplane will remain controllable, maneuverable, and stable during icing encounters. Even small amounts of ice on a wing's leading edge and upper surfaces can have a dramatic effect on lift; therefore, it is a common practice in the airplane manufacturing industry to increase scheduled speeds and stall warning activation thresholds when ice protection systems are activated. Manufacturers are required to ensure that a means is available for pilots to identify the formation of ice on critical parts of the airplane and to provide pilots with information on safe operation in icing conditions (including use of ice protection systems).

The FAA considers visual inspection of wing surfaces by the pilot to be an acceptable means of identifying ice formation. However, under some conditions, ice accretion could be difficult for pilots to identify, and other means of ice detection have also been developed. These include illuminated probes that are visually inspected and typically located on the nose of the airplane forward of the windscreen and magnetostrictive ice detection systems that are mounted on engine cowls and provide electronic indications inside the cockpit of ice accretion on the engine cowls. Because pilots do not always notice relevant cues or follow published procedures for severe icing encounters, one manufacturer developed an aircraft performance monitoring system to alert pilots to monitor for icing conditions if the airplane's actual performance is less than the expected performance (NTSB 2011 and discussed further in the next section).

1.11.3 Previously Issued Safety Recommendations

Out of concern for the potential unreliability of pilot visual detection, assessment, and response to icing conditions, the NTSB has issued many safety recommendations suggesting design-based strategies for enhanced pilot awareness of ice accretion. As a result of the October 31, 1994, accident involving American Eagle flight 4184, an Avions de Transport Régional (ATR)-72-210, which crashed in a field in Roselawn, Indiana, shortly after being cleared to continue a holding pattern, the NTSB issued Safety Recommendation A-96-69 asking that the FAA do the following (NTSB 1996):

[24] In addition to the EMB-500, the Cessna Citation CE510 Mustang, HondaJet, and Eclipse 550 are currently in production. To date, about 300 EMB-500s and about 400 CE510s have been delivered. Delivery for HondaJets began in December 2015, and about 12 Eclipse 550s had been delivered by the end of 2015.

> Conduct or sponsor research and development of on-board aircraft ice protection and detection systems that will detect and alert flight crews when the airplane is encountering freezing drizzle and freezing rain and accreting resultant ice.

Shortly after it was issued, this recommendation was placed on the NTSB's Most Wanted List (MWL). In correspondence with the FAA, the NTSB noted that the commercial development and testing of systems capable of indicating supercooled large droplet conditions were encouraging and satisfied the intent of the recommendation; thus, the NTSB classified Safety Recommendation A-96-69 "Closed—Acceptable Alternate Action" in January 2003.

After a January 2, 2006, incident near San Luis Obispo, California, involving a Saab SF340 airplane that departed controlled flight after encountering icing conditions during its en route climb, the NTSB issued Safety Recommendation A-06-50, asking that the FAA "require the installation of an icing detection system on Saab SF340 series airplanes."[25] The FAA responded that ice detection systems are unnecessary if pilots are required to activate deicing systems based on temperature and the presence of visible moisture rather than waiting for visible signs of ice accretion. As a result, the FAA mandated a modification to the Saab SF340 AFM instructing pilots to use the deice system whenever they are in visible moisture and the temperature is below a certain threshold. The FAA indicated that it considered this a more conservative approach to ensuring that ice protection systems will be used in icing conditions and that pilots will have the benefit of related protections. The NTSB found the modification to the AFM to be an acceptable alternative to the recommendation and classified it "Closed—Acceptable Alternate Action" in February 2009.

After the January 27, 2009, accident involving Empire Airlines flight 8284, an ATR 42-320, which crashed short of the runway while making an instrument approach in icing conditions to Lubbock Preston Smith International Airport, Lubbock, Texas, the NTSB issued Safety Recommendation A-11-44 asking that the FAA—in keeping with similar action taken by the European Aviation Safety Agency (EASA)—do the following (NTSB 2011):

> Require all [US] operators of…ATR 42- and ATR 72-series airplanes to retrofit the airplanes with an aircraft performance monitoring system if they are not already so equipped.[26]

In response, the FAA noted that, in half of the 10 icing-related events cited by EASA when it required European operators to install performance monitoring systems, flight crews were aware that they were in severe icing conditions but did not follow operating limitations. The FAA reasoned that although a performance monitoring system would have provided an alert in all but one of these cases, "it cannot be determined if the flight crew[s] would have acted any differently in response to an…alert than they did to observing the severe icing cues." The NTSB disagreed, noting that in times of high workload, an alert (even a few seconds earlier) that ice

---

[25] The July 10, 2006, safety recommendation letter can be found by accessing the Safety Recommendations link at www.ntsb.gov/air.

[26] Developed by ATR and installed in new production ATR 42- and 72-series airplanes since late 2005, aircraft performance monitoring systems enhance a flight crew's ability to detect the effects of severe icing conditions on an airplane by providing alerts when low airspeed or performance degradation is detected.

accretion has progressed from normal to severe would be beneficial because it would allow the flight crew to take immediate action. Because the FAA indicated that it did not plan to take further action, the NTSB classified Safety Recommendation A-11-44 "Closed—Unacceptable Action" in December 2011.

Recorders can help investigators identify safety issues that might otherwise be undetectable, which is critical to the prevention of future accidents. NTSB safety recommendations have addressed the need for recording information on turbine-powered aircraft (including the model involved in this accident) that are not required to be equipped with a crash resistant recorder system. As a result of the August 26, 2011, accident in which a Eurocopter AS350 B2 helicopter, N352LN, crashed following a loss of engine power as a result of fuel exhaustion near the Midwest National Air Center, Mosby, Missouri, the NTSB issued Safety Recommendation A-13-13, which asked the FAA to do the following (NTSB 2013):

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder or cockpit voice recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all as specified in Technical Standard Order C197, "Information Collection and Monitoring Systems."

In response, the FAA stated that it did not intend to mandate the equipage of crash-resistant flight recording systems on these aircraft. The FAA's reasons were associated with developing a cost-benefit analysis (CBA) required to show a positive benefit. Among the difficulties with the development of this CBA were issues with estimating the number of lives that could be saved or the number of future accidents that could be prevented as a direct result of the additional data provided by recorders. The FAA also indicated that as an alternative to a requirement for recorders, it has programs "promoting and incentivizing the voluntary equipage of crash-resistant flight recording systems." On October 23, 2014, the NTSB reiterated Safety Recommendation A-13-13 as a result of the investigation of a November 10, 2013, accident in Owasso, Oklahoma, involving a Mitsubishi MU-2B-25. In that investigation, the lack of available data significantly increased the difficulty of determining the specific factors that led to the accident.

On November 17, 2014, the NTSB stated in correspondence to the FAA that we were not aware of the FAA's voluntary programs for the equipage of crash-resistant flight recording systems and requested that the FAA provide more information about the programs, including a description of their incentives and any documentation collected indicating that industry was already equipping its fleets. Pending the FAA taking the recommended actions or providing information about an acceptable alternative taken or planned, the NTSB classified Safety Recommendation A-13-13 "Open—Unacceptable Response."

On January 13, 2016, the NTSB announced the 2016 MWL, which included the issue "Expand Use of Recorders to Enhance Transportation Safety." In part, the MWL item states the following:

> Transportation operators and investigators must know what happened in an accident to help prevent such an accident or mitigate the damage done in any future recurrence. No single tool has helped determine what went wrong more than recorders…In aviation, the NTSB recommends the use of cockpit image recorders. We also suggest equipping smaller turbine-powered aircraft with image-recording devices and transport-category and Helicopter Emergency Medical Service rotorcraft with flight recorders. The NTSB encourages operators across the industry to routinely review recorded information in structured programs.

1.11.4 FAA Flight Standardization Board Special Emphasis Training

Relevant to this accident, the FSB report for the EMB-500 outlines the following special emphasis areas (defined as areas that are "unique to the aircraft and should be given a higher degree of emphasis than regular training") for ground and/or flight training:

1. Single Pilot Resource Management, Risk Assessment and Risk Management (ground)
2. Stick Pusher System (ground and flight)
3. Operations in Icing Conditions including Handling Qualities (ground and flight)
4. OPERA (ground)

2. Analysis

2.1 General

The airplane was properly certificated and equipped in accordance with federal regulations. Examination of the airplane wreckage revealed no preimpact malfunctions or failures that would have precluded normal operation of the airplane. The accident was not survivable.

2.2 Pretakeoff Activities

There was no record of the pilot obtaining any weather briefing from an AFSS or DUATS provider. It is therefore not known what source the pilot may have used to obtain his preflight weather briefing. In addition, no evidence was found for and there were no witnesses to the pilot performing weight and balance calculations for the accident flight; however, he usually performed these calculations on his tablet. The CVDR-recorded landing weight for the airplane of 8,277 lbs suggests that the pilot entered about 297 lbs for occupant and cargo weights combined before taking off on the accident flight, resulting in an input almost 400 lbs less than the airplane's actual weight. The NTSB concludes that although the pilot's use of inaccurate occupant and cargo weights had no effect on the airplane remaining within AFM weight and balance limitations, it did influence the landing speeds he selected in preparation for the approach to GAI, which were slower than those that corresponded to the airplane's actual landing weight (the V_{ref} with accurate weight would be 95 knots, and the pilot set the V_{ref} at 92 knots).

The CVDR revealed that the first engine was started about a minute after the airplane was powered up and that it accelerated for takeoff about 5 minutes later, which left the pilot little time to perform the procedures for the Power Up, Before Start, Engine Start (for the second engine), and After Engine Start checklists. Postaccident flight simulations confirmed that all of these procedures would take about 9 minutes to complete. In addition, CVDR evidence showed that the pilot did not perform the check of the airplane's takeoff configuration as specified in the Before Takeoff checklist. The NTSB therefore concludes that the pilot's actions before takeoff for the accident flight were consistent with noncompliance with standard operating procedures (SOP).

2.3 Accident Sequence

The takeoff, climb, and cruise portions of the flight were uneventful. Before and during the airplane's descent from 23,000 ft, the pilot had the AWOS broadcast for the destination airport playing in his headset; the AWOS information indicated that conditions were favorable for structural icing during the airplane's descent and approach. Before the airplane descended through 10,000 ft, the pilot was expected to perform the Descent checklist items, which—depending on the anticipated weather conditions during the descent and approach—he would look up in the Normal checklist or the Normal Icing Conditions checklist. Both checklists are in the QRH, which the pilot should have had available in the airplane during the flight.[27] Based on the AWOS-reported temperature of -1º C and the cloud cover (conditions that were consistent with guidance provided in the QRH), the pilot should have performed the Descent checklist items that appeared in the Normal Icing Conditions checklist, which included turning on the engine anti-ice and wing and horizontal stabilizer deice systems.[28] That action, in turn, would require the pilot to use landing distance performance data that take into account the deice system's activation.

Although the NTSB's investigation could not determine what source the pilot used for his performance calculations, CVDR data show that, almost 2 minutes before the airplane began its descent from 23,000 ft, the pilot entered V_{ref}, V_{ac}, and V_{fs} landing speeds (92, 99, 119 knots, respectively) that were consistent with those indicated in the QRH landing distance performance chart for operation with the wing and horizontal stabilizer deice system turned off, flaps fully deflected, and a maximum airplane landing weight of 8,300 lbs. Thus, the NTSB concludes that the pilot's use of the slower landing speeds in preparation for the approach to GAI is consistent with his referencing the Normal (non-icing) checklist, which does not call for the activation of the wing and horizontal stabilizer deice system, and resulted in band indications on the airspeed display that did not appropriately indicate the stall speed. Using the appropriate Normal Icing Conditions checklist and accurate airplane weight, the pilot should have entered a V_{ref} of 121 knots and flown the approach at 126 knots (a V_{ref} of 121 knots + 5 knots) to account for the forecasted and observed icing conditions.

The CVDR indicated that the TAT was below 10º C when the airplane was at an altitude of about 6,000 ft and was below 5º C when the airplane was at an altitude of about 5,000 ft. The NTSB's aircraft performance study, along with PIREPs of cloud tops and the presence of ice, showed that for several minutes the airplane flew in conditions favorable for structural icing while on approach to GAI. Specifically, the airplane entered the clouds at 1023:41 upon reaching 5,500 ft (the highest cloud height reported), and the pilot reported flying in IMC at 1038:27 while descending through 2,700 ft, indicating that the airplane would have been in visible moisture, an essential element for ice, for at least 15 minutes. While flying between 3,000 and 2,700 ft, the pilot reported being "in and out of the clouds" and in IMC. When the airplane was at 1,450 ft and 2.8 nm from the runway, the pilot acknowledged seeing snow. Therefore, the NTSB concludes that for at least 15 minutes during the descent and approach to GAI, the pilot was operating in an environment conducive to structural icing without either airplane ice protection system activated.

The airplane descended on course and glidepath until about 300 ft above field elevation. At that point, and with the autopilot still engaged, the airplane rolled to a right bank angle of 21º. Less than 1 second later, the first aural stall warning sounded at an airspeed of 88 knots; the autopilot, which is designed to disconnect if a stall warning signal is received, disconnected about the same time. The aural stall warning continued to repeat as the airplane went through a

[27] As mentioned previously, the QRH was not among the documentation recovered from the wreckage but could have been destroyed in the postcrash fire.

[28] The TAT display would have been visible to the pilot and located below and to the left of the PFD.

series of left/right roll oscillations, eventually rolling more than 100º to the right before impact in a left-wing-down attitude.[29]

As mentioned previously, in the airplane's configuration, activating the wing and horizontal stabilizer deice system would cause the stall warning to sound at or above an AOA threshold of 9.5º instead of 21º and the stick pusher to activate at an AOA of 15.5º instead of 28.4º. The NTSB's aircraft performance study found that the airplane began roll oscillations at an AOA of about 16º, its vertical acceleration markedly decreased at about 18º, and it experienced an aerodynamic stall shortly before the aural stall warning sounded at 21º. The airplane's AOA rose above the 9.5º threshold that would have triggered the stall warning if the deice system had been activated about 20 seconds before the loss of control began, so there would have been sufficient warning of an aerodynamic stall had the deice system been used. The NTSB concludes that the pilot's failure to use the wing and horizontal stabilizer deice system during the approach to GAI led to ice accumulation, an aerodynamic stall at a higher airspeed than would occur without ice accumulation, and the occurrence of the stall before the aural stall warning sounded or the stick pusher activated. Once the airplane stalled, its altitude was too low to recover.

2.4 Possible Scenarios for the Pilot's Actions

Based on available evidence, the NTSB could not determine why the pilot did not turn on the wing and horizontal stabilizer deice system during the approach to GAI. The pilot's instructors reported that use of the anti-ice and deice systems was covered during initial and recurrent training; therefore, the pilot was informed about the criteria for using these systems. Further, he turned on the engine anti-ice and wing and horizontal stabilizer deice systems when he encountered conditions conducive to icing shortly after his departure from IGX, which suggests that he knew how the systems worked and when to use them. Therefore, the NTSB concludes that not using the airplane's ice protection systems during the approach to GAI was contrary to the pilot's training and published SOPs and was inconsistent with the pilot's previous behavior during the accident flight. The NTSB considered several possibilities to explain the pilot's actions, which are discussed below.

2.4.1 The Pilot Was Concerned About Landing Distance

QRH performance data indicated that the airplane's weight (whether its actual landing weight or the lesser weight recorded by the CVDR) was outside published limitations for landing at GAI with full flaps and the wing and horizontal stabilizer deice system activated because it would have had insufficient climb performance on one engine if a go-around was required. The airplane's weight would not have been outside limitations due to climb performance if the pilot had decided to land with a flaps 3 setting. In either configuration (flaps full or flaps 3), aircraft operating manuals indicated that the best-case landing distance (that is, the unfactored distance demonstrated by the manufacturer's test pilots during certification flight testing) with the deice

[29] According to the FAA FSB Report for the EMB-500, the altitude lost during stall recovery will be 300 to 500 ft.

system activated and the required use of the associated higher approach speeds was only about 100 ft less than the available runway length at GAI of 4,202 ft.

In either case, the landing distance provided only about 100 ft of stopping margin, so the pilot ran a significant risk of experiencing a runway excursion if he did not flawlessly execute the approach and landing. Given the pilot's previous runway excursion accident at GAI, he was likely highly motivated to avoid this scenario. However, with the wing and horizontal stabilizer deice system selected to off, the pilot would be able to fly slower approach speeds and would have a more comfortable 1,700-ft stopping margin. Therefore, it is possible that the pilot avoided using the deice system to reduce the risk of a runway excursion.

2.4.2 The Pilot Forgot to Activate the Deice System

The approach phase of flight entails a high workload for pilots relative to other phases, which can sometimes cause pilots to become fixated on certain tasks to the exclusion of others. As stated previously, the accident pilot's first EMB-500 instructor stated that the pilot had difficulty with planning and workload management and sometimes became "task saturated," freezing up or fixating on a subtask at the expense of other critical subtasks. This tendency suggests the possibility that, perhaps due to task saturation or high workload, the pilot forgot to activate the wing and horizontal stabilizer deice system during the approach to GAI.

As the FAA noted concerning Safety Recommendation A-06-50, pilots' use of temperature and visible moisture criteria as a basis for activating the deice system is more conservative than relying on pilots to visually detect and evaluate ice accretion. However, the effectiveness of this strategy still relies on consistent pilot adherence to manufacturer guidance about when to activate the system; with the advent of single-pilot, high-performance jets, the NTSB believes that this strategy should be revisited.

Part 91 operations do not share the same regulatory and organizational controls as Part 121 and 135 operations, which have more stringent requirements, oversight, and training that can all help to promote consistency in performance. Furthermore, in a single-pilot operation, the workload is not divided, even in a high-workload situation, and no additional crewmember is present to help detect an error of omission. Although the NTSB is not aware of any events involving similar airplanes and circumstances as those involved in this accident, we are concerned that, as more airplanes with complex icing-related performance requirements are manufactured, more general aviation pilots will be exposed to icing hazards and believe that it would be prudent for pilots to be reminded to activate ice protection systems. The NTSB concludes that providing pilots of turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions with automatic alerting about the need to activate ice protection systems would reinforce this critical procedure while operating in potential icing conditions—especially in single-pilot operations.

Because pilots who may have neglected to activate the ice protection systems per procedures would receive a reminder of the need to do so, the NTSB believes that the benefit of active alerting to support the safe operation of this group of airplanes in icing conditions outweighs any potential drawbacks related to pilot overreliance on such prompting. A performance monitoring system similar to that used on ATR 42- and 72-series airplanes or a cockpit visual or aural alert are examples of potentially effective methods of automatic alerting, but other methods may be more appropriate. Therefore, the NTSB recommends that the FAA and the General Aviation Manufacturers Association work together to develop a system that can automatically alert pilots when the ice protection systems should be activated on turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions.

2.4.3 The Pilot Did Not Accurately Assess the Effect of Icing Conditions on Airplane Performance

The FSB determined type-rating training requirements for the EMB-500 during airplane certification. Among the nine areas of ground training "special emphasis" that the FSB identified for the EMB-500 are single pilot resource management, risk assessment and risk management, OPERA, operations in icing conditions including handling qualities, and the stick pusher system (FSB 2010). The latter two items were also listed as special emphasis flight training areas. Although all of these topics are germane to the performance-related effects of airframe icing, the FSB report does not provide specific details about how these topics were to be addressed and how they related to one another. A review of the FSB report for the Cessna Citation CE510 Mustang and Eclipse 500 revealed the same shortcomings.[30]

The accident pilot was new to the EMB-500 and its associated systems, including the SWPS, which has warning thresholds that change depending on a set of variables. Although he had previously owned a Socata TBM-700 (which was also equipped with deice boots), full flap approach speeds for the Socata TBM-700 are only 10 knots faster in icing conditions than in non-icing conditions, compared to 26 knots faster for the EMB-500. For the accident pilot to safely operate the EMB-500, it was essential that he thoroughly understand the icing-related effects on the performance of the EMB-500 and how not using the airplane's wing and horizontal stabilizer deice system, with even small amounts of ice accretion, could result in extremely hazardous low-speed handling characteristics.

The accident pilot was not a professional pilot, which means that he did not fly as regularly as many professional pilots (only 6 or 7 flight hours per month in the 2 months before the accident). While two of the pilot's instructors said that he was proficient by the time he passed his check ride and that all of the required special emphasis areas were addressed in some manner, CVDR evidence from the flight before the accident flight—as well as errors that the pilot made during the accident flight—revealed weaknesses in his capabilities.

[30] The Eclipse 550 is a second generation Eclipse 500, which went out of production in 2008 due to lack of funding.

The NTSB is aware that the National Business Aviation Association (NBAA) maintains a safety committee that has identified a need for improved training programs for pilots of these airplanes (NBAA 2016).[31] The NBAA points out the following:

> [VLJ pilots[32]] will come from varied levels of experience ranging from the relatively inexperienced to the veteran professional aviator. It is imperative that all candidates successfully completing VLJ training demonstrate a level of proficiency and operational knowledge beyond that required to merely "pass the check ride."

Toward that end, the NBAA has formed a working group that is focused on developing training guidelines and mentor programs aimed at helping pilots of turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions to develop the desired level of proficiency.

As part of its training guideline development process, the NBAA identified 21 areas of risk that were highlighted during visits with manufacturers of these airplanes. Included in this list was the topic "winter operations," which included subtopics involving airframe contamination and related decision-making (NBAA 2016). Another high-level area of risk was identified as "single pilot adherence to checklists," including subtopics related to complacency resulting from the seeming simplicity of these airplanes and degradation of system knowledge. The NTSB believes that all of these topics are potentially relevant to this accident.

Thus, the NTSB concludes that improvements in pilot training for turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions regarding the use of ice protection systems and avoidance of stall-related accidents associated with airframe ice accumulation would help ensure that, especially when conducting single-pilot operations in these airplanes, pilots are aware of safety issues that could have life-threatening consequences. The NTSB believes that the NBAA safety committee is well positioned to lead such an effort by working with the manufacturers of these airplanes who are also members of the NBAA. Further, the NBAA presents at owner conferences annually (such as the Embraer Owners Association and the Cessna Jet Pilots Association), which are outreach opportunities to share this information with owners and pilots who may not be members.

Therefore, the NTSB recommends that the NBAA work with its members that are manufacturers and training providers of turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions to develop enhanced pilot training guidelines pertaining to risk management in winter weather operations, including the use of ice protection systems and adherence to checklists, with special emphasis given to deficiencies

---

[31] The NBAA is an organization founded in 1947 that represents over 10,000 companies that rely on general aviation aircraft and is dedicated to fostering the development of business aviation in the United States and around the world.

[32] The NBAA refers to airplanes like the EMB-500 as very light jets, or VLJs. In the absence of an official definition of the features that characterize a VLJ, this report refers to them as turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions.

in pilot performance identified in this accident, and make the results of this effort available to the community of pilots who fly these airplanes.

2.5 Benefits of Flight Recorders

As a result of the audio and parametric data recorded on the CVDR from the accident airplane, investigators were able to determine critical aspects of the accident flight, including that the pilot did not turn on the wing and horizontal stabilizer deice system during the approach to GAI and that the airspeeds flown were inappropriate for the environmental conditions. Further, the recorded data were a key part of the NTSB's aircraft performance study to determine whether structural icing might have played a role in the circumstances leading to the accident. The cockpit voice recording also provided extensive information for evaluating human performance and operational factors, including the pilot's omission of a built-in takeoff configuration test, his confirmation of visible precipitation during the arrival, and his likely omission of key operational checklists.

The NTSB believes that this investigation is another example of the importance of requiring recorders in advanced aircraft with complex systems. As previously noted, the accident airplane was not required to have any type of crash-resistant recorder installed. However, the manufacturer fortunately decided to install a CVDR unit as basic equipment in the EMB-500. The NTSB concludes that Embraer's decision to install a CVDR in the EMB-500 fleet greatly benefited this investigation by ensuring investigators had access to critical information for determining the sequence of events that led to the accident and identifying actions needed to prevent a similar accident in the future.

3. Conclusions

3.1 Findings

1. The airplane was properly certificated and equipped in accordance with federal regulations.

2. Examination of the airplane wreckage revealed no preimpact malfunctions or failures that would have precluded normal operation of the airplane.

3. The pilot's actions before takeoff for the accident flight were consistent with noncompliance with standard operating procedures.

4. Although the pilot's use of inaccurate occupant and cargo weights had no effect on the airplane remaining within EMB-500 *Airplane Flight Manual* weight and balance limitations, it did influence the landing speeds he selected in preparation for the approach to Montgomery County Airpark, which were slower than those that corresponded to the airplane's actual landing weight.

5. The pilot's use of the slower landing speeds in preparation for the approach to Montgomery County Airpark is consistent with his referencing the Normal (non-icing) checklist, which does not call for the activation of the wing and horizontal stabilizer deice system, and resulted in band indications on the airspeed display that did not appropriately indicate the stall speed.

6. For at least 15 minutes during the descent and approach to Montgomery County Airpark, the pilot was operating in an environment conducive to structural icing without either airplane ice protection system activated.

7. Not using the airplane's ice protection systems during the approach to Montgomery County Airpark was contrary to the pilot's training and published standard operating procedures and was inconsistent with the pilot's previous behavior during the accident flight.

8. The pilot's failure to use the wing and horizontal stabilizer deice system during the approach to Montgomery County Airpark led to ice accumulation, an aerodynamic stall at a higher airspeed than would occur without ice accumulation, and the occurrence of the stall before the aural stall warning sounded or the stick pusher activated. Once the airplane stalled, its altitude was too low to recover.

9. Providing pilots of turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions with automatic alerting about the need to activate ice protection systems would reinforce this critical procedure while operating in potential icing conditions—especially in single-pilot operations.

10. Improvements in pilot training for turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions regarding the use of ice protection systems and avoidance of stall-related accidents associated with airframe ice accumulation would help ensure that, especially when conducting single-pilot operations in these airplanes, pilots are aware of safety issues that could have life-threatening consequences.

11. Embraer's decision to install a cockpit voice and data recorder in the EMB-500 fleet greatly benefited the National Transportation Safety Board's investigation of the December 8, 2014, accident near Montgomery County Airpark by ensuring investigators had access to critical information for determining the sequence of events that led to the accident and identifying actions needed to prevent a similar accident in the future.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's conduct of an approach in structural icing conditions without turning on the airplane's wing and horizontal stabilizer deice system, leading to ice accumulation on those surfaces, and without using the appropriate landing performance speeds for the weather conditions and airplane weight, as indicated in the airplane's standard operating procedures, which together resulted in an aerodynamic stall at an altitude at which a recovery was not possible.

4. Recommendations

To the Federal Aviation Administration:

> Work with the General Aviation Manufacturers Association to develop a system that can automatically alert pilots when the ice protection systems should be activated on turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions. (A-16-12)

To the General Aviation Manufacturers Association:

> Work with the Federal Aviation Administration to develop a system that can automatically alert pilots when the ice protection systems should be activated on turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions. (A-16-13)

To the National Business Aviation Association:

> Work with your members that are manufacturers and training providers of turbofan airplanes that require a type rating and are certified for single-pilot operations and flight in icing conditions to develop enhanced pilot training guidelines pertaining to risk management in winter weather operations, including the use of ice protection systems and adherence to checklists, with special emphasis given to deficiencies in pilot performance identified in this accident, and make the results of this effort available to the community of pilots who fly these airplanes. (A-16-14)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CHRISTOPHER A. HART
Chairman

ROBERT L. SUMWALT
Member

BELLA DINH-ZARR
Vice Chairman

EARL F. WEENER
Member

Adopted: June 7, 2016

5. References

FSB. 2010. *Flight Standardization Board Report, Embraer-Empresa Brasileira de Aeronautica S.A. Models EMB-500 and EMB 505*. Kansas City, MO: Federal Aviation Administration.

NBAA. 2016. *Very Light Jet Training Guidelines.* http://www.nbaa.org/ops/safety/vlj/introduction/1-1-background.php (accessed April 1, 2016).

NTSB. 2013. *Crash Following Loss of Engine Power Due to Fuel Exhaustion, Air Methods Corporation, Eurocopter AS350 B2, N352LN, Near Mosby, Missouri, August 26, 2011*. AAR-13/02, Washington, DC: National Transportation Safety Board.

—. 2011. *Crash During Approach to Landing, Empire Airlines Flight 8284, Avions de Transport Régional Aerospatiale Alenia ATR 42-320, N902FX, Lubbock, Texas, January 27, 2009.* AAR-11/02, Washington, DC: National Transportation Safety Board.

—. 1996. *In-flight Icing Encounter and Loss of Control, Simmons Airlines, d.b.a. American Eagle Flight 4184, Avions de Transport Régional (ATR) Model 72-212, N401AM, Roselawn, Indiana, October 31, 1994; Volume 1: Safety Board Report (Revision 9/13/02).* AAR-96/01, Washington, DC: National Transportation Safety Board.

6. Appendix: Cockpit Voice and Data Recorder Transcript

The following is a partial transcript of the L-3/Fairchild FA2100-3083 solid-state combination voice and data recorder, serial number 600192, installed on an Embraer S.A. EMB-500 (Phenom 100), N100EQ, which crashed during approach to Montgomery County Airpark (GAI), Gaithersburg, Maryland.

LEGEND	
CAM	Cockpit area microphone voice or sound source
HOT	Flight crew audio panel voice or sound source
RDO	Radio transmissions from N100EQ
APR-POT	Radio transmission from a Potomac Approach controller
APR-RDU	Radio transmission from a Raleigh Approach controller
CTR-JAX	Radio transmission from a Jacksonville Center controller
CTR-WAS	Radio transmission from a Washington Center controller
AWU	Aural Warning Unit
EICAS	Engine Instrument Crew Alerting System
AWOS **-GAI** **-IGX**	Automated Weather Observing System at Montgomery County Airpark, Gaithersburg, Maryland at Horace Williams Airport, Chapel Hill, North Carolina
ATIS-RDU	Automatic Terminal Information Service at Raleigh Durham Airport
UNICOM	Aeronautical advisory station (as defined in 47 CFR 87.213)
CTAF	Common Traffic Advisory Frequency
-1	Voice identified as the accident pilot
-2	Voice identified as the cockpit passenger on the accident flight
-3	Voice identified as the cabin passenger on the accident flight
-4	Voice identified as the cockpit passenger on the flight prior to accident flight
-CHA	Content recorded on CVR channel A (cockpit passenger channel)
-CHB	Content recorded on CVR channel B (pilot's channel)
-AC*n*	Transmission from another aircraft (where *n* is replaced with an integer number to uniquely identify the other aircraft)
-?	Voice unidentified
*	Unintelligible word
#	Expletive
( )	Questionable insertion
[ ]	Editorial insertion

Note 1: Times are expressed in eastern daylight time (EST).
Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.
Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.
Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft.

CVR Quality Rating Scale

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information:

Excellent Quality	Virtually all of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate only one or two words that were not intelligible. Any loss in the transcript is usually attributed to simultaneous cockpit/radio transmissions that obscure each other.
Good Quality	Most of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.
Fair Quality	The majority of the crew conversations were intelligible. The transcript that was developed may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.
Poor Quality	Extraordinary means had to be used to make some of the crew conversations intelligible. The transcript that was developed may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio) or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.
Unusable	Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:08:27.9 **CAM**	[decrease in background sound]		
10:08:28.5 **HOT-1**	turn that off that's too cold for me. okay that's.		
		10:08:44.6 **AWOS-CHB at GAI**	[AWOS begins at low volume CHB (Person 1's channel) and continues until 10:10:03]
10:10:35.6 **AWU**	vertical track. [similar to vertical track correction warning]		
10:11:33.3 **CAM**	[reduction in background sound, similar to throttle reduction]		
10:11:53.8 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:12:24.1 **CTR-WAS**	november one zero zero echo quebec contact Washington Center one three three point two.
		10:12:27.8 **RDO-1**	thirty three two for a hundred echo quebec. thanks.
10:12:43.9 **CAM**	[reduction in background sound, similar to throttle reduction]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:12:45.5 **RDO-1**	one hundred echo quebec is with you out of ah twenty point nine for fifteen.
		10:12:53.8 **CTR-WAS**	november one zero zero echo quebec Washington Center roger. expedite your descent ah your expecting fifty-five miles southwest of Martinsburg at niner thousand.
		10:13:03.6 **RDO-1**	fifty-five west [emphasis on west] of Martinsburg at ah nine. is that correct? you want us to put that in as a restriction?
		10:13:08.8 **CTR-WAS**	november zero echo quebec your expecting ah fifty-five miles southwest of Martinsburg at niner thousand.
		10:13:14.1 **RDO-1**	okay we'll expect that one hundred echo quebec.
		10:14:09.3 **AWOS-CHB at GAI**	[AWOS begins at low volume CHB (Person 1's channel) and continues until 10:23:23]
10:14:12.5 **HOT-1**	wow a lot of traffic.		
10:14:14.4 **HOT-2**	yeah.		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:14:44.5 **CTR-WAS**	november one hundred echo quebec cross five-five miles southwest of Martinsburg at and maintain niner thousand.
		10:14:49.2 **RDO-1**	fifty-five west of Martinsburg at nine one hundred echo quebec.
10:15:15.4 **HOT**	[sound of c-chord, similar to altitude alerter]		
10:16:00.1 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:16:38.3 **RDO-1**	and one hundred echo quebec you gave us a restriction which was a little bit difficult to get. but I just wanted to let you know we are on the way down.
10:16:56.6 **CAM**	[slight increase in background noise, similar to throttle increase]		
10:17:03.2 **HOT-?**	***.		
10:17:55.9 **CAM**	[slight decrease in background noise, similar to throttle decrease]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:18:32.7 **CTR-WAS**	november one zero zero echo quebec descend and maintain seven thousand.
		10:18:35.7 **RDO-1**	seven thousand one hundred echo quebec.
		10:18:37.9 **CTR-WAS**	* echo quebec contact Potomac Approach one two zero point four five. good day.
10:18:38.8 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:18:41.6 **RDO-1**	two zero. two zero point four five one hundred echo quebec.
		10:18:46.7 **RDO-1**	and approach one hundred echo quebec is with you on the way down to seven.
		10:18:49.6 **APR-POT**	* one zero zero echo quebec Potomac Approach roger. Dulles altimeter three zero five eight. descend and maintain five thousand.
10:18:50.1 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:18:56.4 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:18:56.5 **RDO-1**	five thousand one hundred echo quebec.
		10:19:08.7 **APR-POT**	(Phenom) one zero zero echo quebec how did they file you to Gaithersburg?
		10:19:12.3 **RDO-1**	uhm Martinsburg uhm Westminster direct.
		10:19:48.5 **APR-POT**	* zero quebec good rate down through ah nine thousand please. [static in APR-POT radio call]
		10:19:53.9 **RDO-1**	one hundred echo quebec say again (please).
		10:19:56.4 **APR-POT**	Phenom zero echo quebec good rate through niner thousand please.
		10:20:01.3 **RDO-1**	alright expedite through nine. was that correct for (one) hundred echo quebec?
		10:20:04.2 **APR-POT**	Phenom zero echo quebec affirmative. no delay through nine descend and maintain five thousand.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:20:08.3 **RDO-1**	okay we'll expedite through nine down to five one hundred echo quebec.
		10:20:47.1 **AWOS-GAI**	[AWOS continues, louder on both channels]
10:21:06.2 **HOT-2**	* alright.		
		10:21:07.1 **AWOS-CHB at GAI**	[AWOS louder on CH-B (Person 1's channel)]
		10:21:15.0 **APR-POT**	["november one zero zero echo quebec" only recorded on CH-A (Person 2's channel)] [transmission continues on both channels A and B] contact approach one two six point one.
		10:21:23.6 **APR-POT**	Phenom zero echo quebec contact approach one two six point one--one two six point one for Phenom zero echo quebec.
		10:21:31.1 **RDO-1**	twenty. one twenty six point one for a hundred echo quebec. thanks.
		10:21:38.6 **RDO-1**	and approach one hundred echo quebec is with you out of eight point two for five.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:21:41.8 **AWOS-GAI**	[AWOS has been playing at increasing volume on CH-A and CH-B] weather observation one five two one zulu. weather. wind zero seven zero at five. visibility more than one zero. sky condition few clouds at two thousand three hundred...
		10:21:55.4 **APR-POT**	november ah one hundred echo quebec Dulles Altimeter is three zero five eight. verify you have the weather and say approach request.
		10:22:02.5 **RDO-1**	ah hundred echo quebec we do. could we get the G-P-S one four and we'll circle to land three two.
		10:22:06.9 **APR-POT**	(okay) expect that.
		10:22:15.8 **RDO-1**	no actually well why don't we just do the-the G-P-S 14 to begin with. one hundred echo quebec.
		10:22:21.3 **APR-POT**	alright.
		10:23:00.2 **AWOS-GAI**	[AWOS volume increases notably on CH-B (Person 1's channel)] S-F-R-A rules are in effect. do not squawk twelve hundred at anytime. deer and birds have been seen on the airfield. fly over Gaithersburg airport at two thousand feet. runway three two is right hand pattern.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:23:22.7 **AWOS-GAI**	Montgomery County Airpark * automated weather observation one five two three zulu. weather. wind zero seven zero [volume increases] at six. visibility more than one zero. sky condition two thousand one hundred scattered. ceiling three thousand overcast. temperature minus one Celsius. dewpoint minus niner Celsius. altimeter [volume lowers on CH-B (Person 1's channel)]. [AWOS stops on CH-B, continues on CH-A]
10:23:24.1 **HOT**	[sound of c-chord, similar to altitude alerter]		
10:23:47.0 **HOT-1**	alright.		
10:23:52.2 **HOT-1**	[sound of exhale]		
		10:24:10.3 **RDO-1**	and ah (one) hundred echo quebec if you'de ah if we could get BEGKA direct ah when you're able that would be great. thanks.
		10:24:18.6 **APR-POT**	november zero echo quebec roger. fly heading ah zero six zero for now.
		10:24:22.3 **RDO-1**	zero six zero. one hundred echo quebec.
		10:26:21.7 **APR-POT**	* zero echo quebec fly heading zero eight zero.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:26:24.2 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:26:24.6 **RDO-1**	zero eight zero. one hundred echo quebec.
		10:27:38.3 **AWOS-GAI**	[AWOS plays again at higher volume (both channels)] Montgomery County Airpark automated weather observation one five two seven zulu. weather. wind zero six zero at six. visibility more than one zero. sky condition few clouds at two thousand one hundred. ceiling three thousand overcast. temperature minus one Celsius. dewpoint minus eight Celsius. altimeter three zero six one. remarks S-F-R-A rules are--- [AWOS stops on both channels]
		10:28:27.4 **APR-POT**	zero echo quebec proceed direct BEGKA. descend and maintain four thousand.
10:28:30.8 **CAM**	[sound of click]		
		10:28:31.0 **RDO-1**	direct BEGKA down to four one hundred echo quebec. thanks.
10:28:33.1 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:28:41.2 **CTAF**	[CTAF transmissions begin on both CH-A (Person 2) and CH-B (Person 1) until end of recording. Additionally, APR-POT is also on both channels (simultaneous with CTAF) until CH-B ends APR-POT at 10:34:43 (CH-A receives APR-POT until end of recording)]
		10:28:42.0 **CTAF-AC1**	one five echo do you copy?
10:28:43.9 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:28:46.0 **CTAF-AC2**	hey this is five echo. what's up?
		10:28:48.0 **CTAF-AC1**	***.
		10:28:50.7 **CTAF-AC2**	ah it looks like it's switchin' between straight down one four and across. so I'd say just use one four if you don't mind.
		10:28:58.5 **CTAF-AC1**	okay.
10:29:02.0 **HOT**	[sound of c-chord, similar to altitude alerter]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:29:08.7 **CTAF-AC2**	we're gonna' be full stop on all of ours. so if you (ever want to switch to that).
		10:29:13.7 **CTAF-AC1**	no. we are leaving.
		10:29:15.1 **CTAF-AC2**	(copy).
		10:29:21.8 **RDO-1**	Montgomery Traffic ah Phenom one hundred echo quebec is out twenty five. we'll be ah on the G-P-S ah fourteen approach.
10:29:34.6 **HOT**	[sound of click]		
		10:29:44.3 **APR-POT**	november zero echo quebec descend and maintain three thousand.
		10:29:47.8 **RDO-1**	three thousand one hundred echo quebec.
10:29:48.0 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
10:30:22.0 **HOT**	[sound of c-chord, similar to altitude alerter]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:30:43.9 **CAM**	[sound of click]		
10:31:11.2 **HOT-1**	ground. I see ground.		
10:31:13.8 **HOT-2**	yep.		
		10:31:20.6 **APR-POT**	november zero echo quebec. one one miles from BEGKA cross BEGKA at three thousand. cleared R-NAV G-P-S one four approach Gaithersburg.
		10:31:28.5 **RDO-1**	BEGKA at one three thousand. cleared for the approach. one hundred echo quebec.
10:34:42.0 **CAM**	[sound of click]		
10:34:57.5 **CAM**	[decrease in background sound, similar to throttle decrease]		
		10:35:03.1 **CTAF-AC3**	Montgomery Traffic november five two six three two departing runway one four Montgomery.
		10:35:13.0 **RDO-1**	Montgomery Traffic ah Phenom one hundred echo quebec is ten out we're just starting G-P-S one four approach.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:35:22.7 **CTAF-AC2**	hey aircraft on (the) G-P-S. ** any precip out there?
		10:35:31.3 **CH-B**	[APR-POT volume lower's on Person 1's radio]
		10:35:33.9 **RDO-1**	Montgomery's a hundred echo quebec. you call us?
		10:35:37.4 **CTAF-AC2**	ah yeah. just ah seein' if you got. we're on the ground here. seein' if you're gettin' any precip out there.
		10:35:40.8 **APR-POT**	[this transmission was only recorded on CH-A (Person 2)] november zero echo quebec advise cancellation of IFR on this frequency on the air or ** ground.
		10:35:42.5 **RDO-1**	ah we're kind of in and out of the clouds here.
		10:35:45.0 **CTAF-AC2**	roger.
		10:35:47.0 **RDO-1**	and that's at three thousand.
		10:35:49.4 **CTAF-AC2**	roger.
		10:36:02.8 **CTAF-AC2**	Tiger you gonna turn in here?

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:36:15.1 **CTAF-AC2**	Tiger are you comin' in here?
		10:36:21.6 **CTAF-AC4**	* a Tobago.
		10:36:23.7 **CTAF-AC2**	my mistake. Tobago are you comin' in here?
		10:36:28.4 **RDO-1**	if you're talkin' to Phenom one hundred echo quebec. we are.
		10:36:35.0 **CTAF-AC2**	not for you. tryin' to coordinate on the ground here.
		10:36:50.4 **CTAF-AC3**	* six three two. crosswind one four Montgomery.
		10:37:15.8 **CTAF-AC3**	Montgomery Traffic five two six three two turning downwind one four Montgomery.
10:37:32.8 **CAM**	[increase in background sound, similar to throttle increase]		
10:37:44.4 **CAM**	[increase in background sound, similar to throttle increase]		
10:38:12.1 **CAM**	[slight decrease in background sound, similar to throttle decrease]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:38:18.2 **CAM**	[slight decrease in background sound, similar to throttle decrease]		
		10:38:20.2 **APR-POT**	november one zero quebec you still with me?
		10:38:22.9 **RDO-1**	one hundred echo quebec sure are.
		10:38:24.4 **APR-POT**	sorry. what was your response to cancelling?
		10:38:26.8 **RDO-1**	ah we're I-M-C at the moment. but we should be ah we should be clear in just a minute or two. we'll let you know.
		10:38:32.3 **APR-POT**	** quebec roger. that's fine. change to advisory frequency approved. * remain * squawk until landing. and do not forget to cancel.
10:38:33.8 **HOT**	[sound of c-chord, similar to altitude alerter] [sound of c-chord, similar to altitude alerter]		
10:38:35.9 **AWU**	altitude. [similar to altitude correction warning]		
10:38:38.1 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:38:39.2 **RDO-1**	okay. hundred echo quebec.
10:38:47.9 **CAM**	[sound of rotary dial, similar to altitude and/or heading and/or course knob movement]		
		10:38:50.9 **CTAF-AC2**	Montgomery Traffic five two one five echo departing runway one four. Montgomery Traffic.
10:38:53.8 **CAM**	[slight decrease in background sound, similar to throttle decrease]		
		10:39:01.2 **CTAF-AC2**	(@) use caution. numerous birds in the vicinity of the runway.
		10:39:04.9 **CTAF-(AC3)**	in sight.
		10:39:06.6 **RDO-1**	and Montgomery one hundred echo quebec is now at seven miles straight in one four.
		10:39:10.7 **CTAF-AC3**	Montgomery Traffic five two six three two is turning base one four Montgomery.
10:39:13.9 **CAM**	[slight decrease in background sound, similar to throttle decrease]		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:39:14.7 **CAM**	[sound of two clicks]		
10:39:21.6 **HOT-1**	kay. so your job is to find the airport.		
10:39:24.2 **HOT-2**	[laughter]. uh huh.		
10:39:26.1 **HOT-1**	just look straight ahead and say airport in sight [chuckling].		
		10:39:29.3 **CTAF-(AC2)**	hey @ watch out for birds in the vicinity of ah one four.
		10:39:33.4 **CTAF-AC1**	okay. thanks.
		10:39:34.7 **CTAF-(AC2)**	(roger).
10:39:35.4 **HOT-1**	we're still ah two point two about five seven miles out. so.		
		10:39:35.5 **CTAF-AC1**	***.
		10:39:41.3 **CTAF-AC1**	how is it?
		10:39:42.3 **CTAF-???**	yeah man.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:39:46.5 **CTAF-AC1**	who?
		10:39:47.3 **CTAF-AC5**	(@).
		10:39:48.1 **CTAF-AC1**	hey what's up.
		10:39:49.9 **CTAF-AC5**	I'm good. (what are you doin?)
10:39:50.2 **CAM**	[sound of background static (about 49 seconds in duration)]		
		10:39:52.7 **CTAF-AC1**	(sleeping.)
		10:39:54.0 **CTAF-???**	[laughter]
		10:39:59.3 **CTAF-AC3**	Montgomery Traffic five two six three two is final one four Montgomery.
10:40:03.4 **HOT-2**	snow.		
		10:40:05.0 **RDO-1**	and Montgomery Traffic Phenom one hundred echo quebec is six out straight in one four.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:40:10.6 **HOT-1**	wow there's snow.		
10:40:12.0 **HOT-2**	yeah.		
10:40:12.8 **HOT-1**	who else.		
		10:40:14.7 **CTAF-(AC5)**	alright (@) talk to you later.
		10:40:16.5 **CTAF-AC1**	okay. take care.
		10:40:17.9 **CTAF-(AC5)**	bye-bye.
		10:40:19.8 **CTAF-AC2**	Montgomery Traffic five two one five echo turning crosswind runway one four Montgomery Traffic.
		10:40:28.7 **CTAF-AC6**	Montgomery Unicom zero zero lima.
		10:40:32.9 **CTAF-UNICOM at GAI**	zero zero lima go ahead.
10:40:34.2 **HOT-(2)**	I think I got it.		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:40:34.3 **CTAF-AC6**	yeah. we got an unusual amount of birds out here on one four ***. bring out the cannon.
10:40:37.1 **HOT-(2)**	oh I see it. I see it. yep.		
10:40:37.1 **HOT-(1)**	there it is.		
10:40:38.9 **HOT-(1)**	straight ahead.		
10:40:39.1 **CAM**	[sound of click]		
10:40:39.7 **HOT-(2)**	yeah.		
		10:40:42.0 **CTAF-UNICOM at GAI**	yeah I'll get Lawnguy out there to do it for you.
		10:40:43.8 **CTAF-AC6**	hey thanks.
		10:40:45.1 **RDO-1**	and Montgomery Traffic Phenom one hundred echo quebec is now three out straight in one four.

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:40:53.6 **CAM**	[sound of multiple clicks]		
		10:41:02.7 **CTAF-AC2**	Montgomery Traffic five two one five echo turning downwind runway one four Montgomery Traffic.
10:41:04.7 **CAM**	[reduction in background sound, similar to throttle decrease]		
10:41:20.1 **CAM**	[slight increase in background sound, similar to throttle increase]		
		10:41:23.2 **CTAF-AC1**	@ are you ah leaving the ah pattern?
10:41:23.9 **AWU**	five hundred.		
		10:41:30.0 **CTAF-AC1**	@ do you copy?
10:41:31.5 **CAM**	[increase in background sound, similar to throttle increase]		
		10:41:31.5 **CTAF-AC2**	one more time.
		10:41:32.5 **CTAF-AC1**	are you leaving the traffic pattern?

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:41:34.5 **CTAF-AC2**	ah we're gonna' go up to twenty five hundred feet ***.
10:41:35.5 **CAM**	[CTAF communications begin being transmitted over the speaker]		
10:41:35.9 **AWU**	stall. stall.		
10:41:37.2 **CAM**	[increase in background sound, similar to throttle increase]		
		10:41:37.9 **CTAF-???**	***.
10:41:38.6 **AWU**	stall. [sound of clunk (on CAM)] stall.		
		10:41:39.5 **CTAF-AC1**	something is coming in.
10:41:41.2 **AWU**	stall. [sound of clunk (on CAM)] stall.		
		10:41:43.4 **CTAF-AC2**	what are you talkin' about. the weather?
10:41:44.0 **AWU**	stall. stall.		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		10:41:44.9 **CTAF-AC1**	*.
		10:41:46.6 **CTAF-AC2**	okay. we'll ah play it by ear.
10:41:46.7 **AWU**	stall. stall.		
10:41:48.4 **HOT-(2)**	oh no.		
10:41:49.3 **HOT-(1)**	whoa.		
10:41:49.4 **AWU**	stall. stall.		
10:41:50.6 **HOT-(1)**	whoa.		
10:41:51.1 **HOT-?**	[loud inhale and exhale]		
10:41:52.1 **AWU**	stall. stall.		
10:41:54.0 **CAM-?**	[unintelligible exclamation]		
10:41:54.8 **AWU**	stall.		

ACCIDENT FLIGHT – DECEMBER 8, 2014

TIME and SOURCE	INTRA-AIRCRAFT CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
10:41:55.2 **CAM-?**	[unintelligible exclamation]		
10:41:55.4 **CAM**	[sound of loud noise, similar to impact]		

END OF TRANSCRIPT
END OF RECORDING
10:41:55.7 EST